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# MONTHLY NOTICES

OF THE

# ROYAL ASTRONOMICAL SOCIETY,

CONTAINING

## PAPERS,

## ABSTRACTS OF PAPERS,

AND

## REPORTS OF THE PROCEEDINGS

OF

## THE SOCIETY,

*FROM NOVEMBER* 1862, *TO JUNE* 1863.

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VOL. XXIII.

BEING THE ANNUAL HALF-VOLUME OF THE MEMOIRS AND PROCEEDINGS OF THE ROYAL ASTRONOMICAL SOCIETY.

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# MONTHLY NOTICES

OF THE

# ROYAL ASTRONOMICAL SOCIETY.

VOL. XXIII. *November* 14, 1862. No. 1.


Dr. LEE, President, in the Chair.

Lieut. Bailey, R.N., H.M.S. Excellent;
Lieut. H. Morland, Ebury Street, Pimlico; and
David Hornby, Esq., 46 Guildford Street,

were balloted for and duly elected Fellows of the Society.

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*Letter from Prof. Grant to the Editor.*

I send you herewith, for insertion in the *Monthly Notices*, a communication which I have received from Prof. Smyth, containing a description of the great equatoreally mounted Refractor, of 11 inches aperture, erected a few years since by J. W. Grant, Esq., of Elchies, Morayshire; also some results of observations made by Prof. Smyth with the same instrument, on the occasion of a visit which he recently paid to Mr. Grant. It may be mentioned that the owner of this magnificent instrument resided many years in India, during which he employed much of the leisure time of an official life in cultivating scientific studies of various kinds, occupying himself occasionally with a 5-foot refractor of excellent quality. As an instance of what an observant eye may effect under favourable circumstances of climate, even although aided by an instrument of only inferior power, it may be stated that the duplicity of *Antares* was recognised by Mr. Grant as early as the 23d of July, 1844, that is to say, *two years anterior* to the discovery of the same interesting fact by the American astronomer, Prof. Mitchell, with the aid of the great Cincinnati Refractor (*Monthly Notices*, vol. xvi. p. 56). Prof. Smyth was recently led to a knowledge of this circumstance by an exami-

nation of Mr. Grant's observation papers. That it was not communicated earlier to the world is accounted for by Mr. Grant's retiring disposition, and by the modest estimation which he has invariably formed of his scientific labours. Prof. Smyth purposes communicating to the Society, on an early occasion, an account of Mr. Grant's astronomical observations in India.

Upon his return to Scotland, about twelve years ago, with the intention of spending the remainder of his life on his patrimonial estate, Mr. Grant resolved to continue his astronomical observations; and with a view to this object, he erected at Elchies* a substantial Observatory, which he fitted up with the great Equatoreal of 11 inches aperture, to which I have already referred. This was the first equatoreally mounted Refractor of considerable magnitude which had hitherto been erected in Scotland: indeed, with the exception of the Equatoreal of nine inches aperture subsequently acquired by the late Sir William Keith Murray, it is the only instrument of the kind deserving of the name which has ever been mounted in the northern part of this island. The unsuitableness of the climate of Elchies for astronomical observations, and recently continued ill-health, have prevented Mr. Grant from availing himself so fully of the advantages of this noble instrument as his Indian experience entitled him to hope for, and as the munificent sacrifice made by him in the cause of science so well merited.

At Prof. Smyth's request I have appended one or two footnotes to his communication, as, from the circumstance of his present temporary residence in the country, his access to original authorities has been necessarily limited.

*Observatory, Glasgow, October 13th*, 1862.

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*Experiences with the Elchies Equatoreally mounted Refractor of 11 inches aperture, in September* 1862. By Prof. C. Piazzi Smyth, Astronomer Royal for Scotland.

### Description of the Instrument.

This is a very remarkable instrument, as well in its mechanical as its optical portions, and I have had an unusual opportunity of becoming practically acquainted with both, during a continued stay of three weeks; for the whole of which time the key of the Observatory, and complete control over,

* Prof. Grant informs me that Elchies is situate about eight miles below the junction of the Spey and the Avon.—Ed.

and employment of, everything therein, were kindly conceded to me by the owner, and with the frequently repeated instructions that I was to employ them as freely as if the entire Observatory had been my own property.

From long remaining unused, a good deal of dust and thickened oil had to be removed before beginning work; but, that once done, all the essentials of the instrument were found in excellent condition, and micrometer observations of double stars were from that time made every fine night, and with a great feeling of satisfaction in the use and working of the instrument.

## Optical Parts.

The object-glass is 11 inches in diameter and 16 feet in focal length. It has a number of minute bubbles in it (as indeed almost every object-glass has, and without further detriment than merely the loss of as much light as they intercept); but I have not been able to see any trace of striæ or positive imperfections in the glass, either by looking at or through it; or, by examining the discs of stellar light, by viewing a bright star, *α Lyræ*, much out of focus, and with a magnifying power of 397.

This power has been employed in all the observations, and with it, notwithstanding the very untoward state of the weather, some excellent proofs have been obtained of both the light-transmitting and the defining powers of the object-glass; though it is believed that better proofs still might be obtained, if a fully good night were to occur, and more difficult test objects to be above the horizon. The results, however, as far as yet secured, may be stated thus:—

In the course of examining a list of twenty-five well-known double stars, there were six cases where one or more additional small stars, not previously known or recorded, were discovered; besides two or three cases where small stars, whose existence had merely been mentioned by other observers, were found bright enough to admit of micrometer measurement in the Elchies telescope, with a position and distance wire micrometer and lamp-illuminated field.

These instances, of which a special list will be appended, and which speak chiefly for the light-transmitting power of the object-glass, were attained, even in spite of such bad definition of the atmosphere, that every star was more or less blurred and nebulous. There have indeed been only two occasions, and then only for a few minutes each time, when the atmosphere quieted and allowed the defining power of the object-glass itself to be studied; the first of these instances was on Sept. 17th, at $1^h$ P.M., when the Pole star was in the field, and looked a minute and brilliant disk with well-shaped thin rings around it, in the bright sunshine; the second was on Sept. 20th, at

$5^h$ $30^m$ A.M., when B of *γ Andromedæ* was distinctly seen as two different and completely separated stars, which were measured accordingly both in position and distance. While that it was a triumph to the object-glass to see them in that manner, I may mention that the disk of each star was considerably less than the diameter of the fine spider's thread of the micrometer, and about 0·3, or 0·4 of a second of space in diameter; the distance apart, from centre to centre, being about 0·6 of a second.

In completion of the optical details it may be mentioned, that there are twenty-three eye-pieces of various powers, in addition to the two of the micrometer; twenty-four caps with coloured glass, several piles of coloured glass disks, screwing into each other, a fine totally reflecting prism of very large size, a dynameter, &c., in two mahogany cases; besides the position wire micrometer in its own box. The telescope has three finders, one of them being a fine 5-foot telescope, and is furnished with an illuminating apparatus for use with the micrometer.

## Mechanical Parts.

### *The Equatoreal Motion.*

The mounting of the Elchies telescope is on the principle known as the German, in contradistinction to the English, or the form with a long polar axis, and the telescope in the middle between the bearings.

The German form, viz., with short polar axis and telescope outside both bearings, is perhaps more frequently employed in every country than the other, and specimens of it in connexion with large telescopes are now numerous; but nowhere over the whole world has so firm, and solid, and well-constructed an example ever been mounted as that of Elchies.

This is saying a great deal, especially in knowledge of the admirable models sent forth to various public and private Observatories by the astronomical factories of Munich, Paris, and York; but I believe it to be perfectly true, and owing, greatly, to the late Mr. A. Ross, the optician of the telescope, having secured the services of Messrs. Ransome and May, Engineers, Ipswich, for the mounting. Messrs. Ransome and May were the firm who had been already selected and employed by the Astronomer Royal, to introduce into the new Greenwich instruments the solidity and improved methods of modern engineering; and I know that they entered with great zeal into the efficient carrying out of Mr. Ross's order, Mr. May himself personally assuring me, that he believed this instrument would be the beginning of a new era in the construction of Equatoreals, by reason of the astonishing firmness and steadiness, combined with truth, which he expected the mass of metal introduced into this one, and duly turned and planed, would impart to its

movements. It was this mounting, accordingly, which attracted such general attention and commendation in the centre of the nave of the British portion of the International Exhibition in 1851, and it commends itself equally now, after eleven years standing in an Observatory.

The declination and polar axes, each about 6 inches in diameter, in solid metal, and 5 feet long, are wonders of strength in connexion with any optical instrument, and could never have been produced by any mere optician; while the gun-metal bearings, and gun-metal circles, together with the gearing and ungearing apparatus for the endless screws, is of a majesty of form, size, and substance, more like steam-engine, than ordinary telescope, fittings.

Both circles, 30 inches in diameter, are cast as disks of gun metal, without any perforations, about 1 inch thick, additionally strengthened towards the centreing, and furnished with rack edge and noble endless screws to work in them, of actually 2·1 inches in diameter; while their end-shake and wear in their bearings is corrected by the efficient method adopted in the shaft of a screw steamer; or, by having a long series of projecting flanges cut on the pivot, and working into a similar series of depressions in the gun-metal bearing.

It will thus be seen that this part of the entire instrument is quite worthy both of the engineering fame of Messrs. Ransome and May, and of their training for astronomical structures under George Biddell Airy; and to their work Mr. Ross has added various fine fittings, graduation on the circles very easily read, an excellent system of double Hooke's-joint handles, workable from the eye-piece of the telescope, and an efficient equatoreal driving clock.

## The Stand.

The mere stand or pier for supporting the bearings of the above-mentioned equatoreal axes of motion, is also a noteworthy point about the Elchies instrument. It is of iron, and by Messrs. Ransome and May also; there are the usual adjustments for the bearings of the axes, and the general form is convenient; but the remarkable and unprecedented thing is the extraordinary amount of weight introduced into it, for the purpose of checking those minute tremors which usually disturb accurate vision in all of the ordinary forms of mountings of large telescopes; and which can only be thoroughly corrected by the absorbing effect of mass. One portion of the stand accordingly weighs no less than eleven tons, and is the greatest quantity of iron ever cast into a single piece for any astronomical instrument of any age or in any country.

In conclusion I have to add, that though the telescope be so large, and the mounting so heavy, and though I have never had experience in the use of so large a telescope before, yet I found

was taken with an unusual micrometer, and, because "illumination was precluded to so small an object as B," appeared in the Bedford telescope. In Mr. Grant's larger telescope, however, B was comparatively so bright that there was no difficulty in illuminating the field and employing the usual wire-micrometer.

$\beta$ Cygni, R.A. $19^h\,25^m\,9^s$, Decl. $+\,27°\,40'\,20''$, Jan. 1, 1862.

| Components. | Mags. | Colours. | Position. | Distance. |
|---|---|---|---|---|
| | | | ° ′ | ″ |
| A | 3 | Yellow | | |
| B | 7 | Blueish-green | A B 55 28 (w. 2·0) | 34·20 (w. 1·0) |
| (New) C | 15·3 | Blue | A C 340 2 (w. 1·0) | 61·49 (w. 0·5) |
| (New) D | 15 | Blue | A D 33 45 (w. 0·5) | 107·50 (w. 0·2) |

Date of observation = 1862·72.

The above magnitudes and colours of A and B coincide closely with those in the "Cycle," or, "3 and 7, and topaz yellow and sapphire blue." The positions and distances show a slight discordance from the authorities quoted or given there; as thus:—

| | Position. | Distance. | Date. |
|---|---|---|---|
| | ° ′ | ″ | |
| B | 57 34 | 34·20 | 1755·00 |
| H | 54 52 | 34·83 | 1782·45 |
| P | 54 31 | 34·28 | 1800·00 |
| Σ | 54 30 | 34·29 | 1821·76 |
| H and S | 54 45 | 34·38 | 1822·98 |
| D | 55 32 | 34·51 | 1830·54 |
| Sm. | 55 24 (w. 5) | 34·2 (w. 5) | 1830·81 |
| Sm. | 55 36 (w. 9) | 34·4 (w. 9) | 1837·58 |

Perhaps the two new stars may assist in proving whether, as has been supposed, both A and B are affected by proper motion, and either one differently.

$\zeta$ Sagittæ, R.A. $19^h\,42^m\,52^s$, and Decl. $+\,18°\,47'\,47''$, Jan. 1, 1862.

| Components. | Mags. | Colours. | Position. | Distance. |
|---|---|---|---|---|
| | | | ° ′ | ″ |
| A | 5·2 | Whitish | | |
| B | 9·7 | Violet | A B 313 19 (w. 2·0) | 8·58 (w. 1·0) |
| (New) C | 15·0 | Blue | A C 250 42 (w. 1·0) | 70·73 (w. 0·5) |

Date of observation = 1862·73.

The above magnitudes and colours again come near those of the "Cycle;" and the positions and distances confirm them

remarkably in a feature where they had differed materially from older authorities, the series running thus:—

| | Position. | Distance. | Date. |
|---|---|---|---|
| | ° ′ | ″ | |
| ♅ | 304 10 | 8·83 | 1781·88 |
| Σ | 309 30 | 8·77 | 1819·74 |
| H and S | 314 32 | 8·82 | 1823·69 |
| H | 318 26 | 9·81 | 1829·63 |
| Sm. | 313 24 (w. 7) | 8·9 (w. 7) | 1831·59 |
| Sm. | 312 18 (w. 9) | 8·6 (w. 9) | 1838·67 |

The reason of these differences, so much larger than ordinary errors of observation, is difficult to conjecture truly, and may imply a dark planet of large size accompanying one of the stars. The new star C, now shown to exist, is too far off in itself to explain such perturbations, but may prove a useful referring point for the future.

452 Cygni, R.A. $20^h\ 57^m\ 4^s$, and Decl. + 38° 58′ 0″, Jan. 1, 1862.

| Components. | Mags. | Colours. | Position. | Distance. |
|---|---|---|---|---|
| | | | ° ′ | ″ |
| A | 6 | Reddish orange | | |
| B | 10 | Greenish | A B 300 33 (w. 2·0) | 19·22 (w. 0·5) |
| (New) C | 13 | Blueish | A C 86 53 (w. 1·0) | 98·01 (w. 0·4) |
| D | 15·5 | Blueish | A D 138 54 (w. 1·0) | 54·29 (w. 0·3) |

Date of observation = 1862·73.

The stars A and B are here each one magnitude larger than in the "Cycle;" the colours are nearly the same; but the position and distance indicate rapid proper motion, being given as 297° 0′ (w. 3) and 17″·0 (w. 1) respectively, in 1832·87. Neither C nor D are measured there, but D is evidently alluded to as a star "of the 13th magnitude, *s f*, and sufficiently near to form with A and B a triple object:" a description which indicates a change of magnitude to have occurred since then.

1 Pegasi, R.A. $21^h\ 15^m\ 43^s$, and Decl. + 19° 12′ 56″, Jan. 1, 1862.

| Components. | Mags. | Colours. | Position. | Distance. |
|---|---|---|---|---|
| | | | ° ′ | ″ |
| A | 4·5 | Yellowish | | |
| B | 9 | Grey | A B 311 16 (w. 2·0) | 36·76 (w. 0·5) |
| (New) C | 14·5 | Blue | A C 22 59 (w. 1·0) | 80·03 (w. 0·3) |

Date of observation = 1862·72.

The magnitudes and colours of A and B, as here detailed, are nearly conformable to those of the Cycle; while the angles

of position and distances accompanying raise their history from "indicating no notable change," in 1833, to exhibiting a regular, though slow, orbital movement in 1862; as thus:—

| | Position. | Distance. | Date. |
|---|---|---|---|
| | ° ′ | ″ | |
| H | 308 19 | 37·10 | 1780·69 |
| S | 310 11 | 36·86 | 1825·22 |
| Sm. | 310 48 (w. 8) | 36·40 (w. 5) | 1833·95 |

The new star C may or may not form a member of the system, of which the proper motion is so very large that there is much need for a heavenly milestone to measure its movements from.

312 Pegasi, R.A. $21^h\,45^m\,6^s$, and Decl. + 19° 10′ 53″, Jan. 1, 1862.

| Components. | Mags. | Colours. | Position. | Distance. |
|---|---|---|---|---|
| | | | ° ′ | ″ |
| A | 7 | Yellowish | | |
| B | 15 | Blueish | A B 92 28 (w. 1·0) | 20·32 (w. 0·5) |
| (Rediscoverd) C | 17 | Blueish | A C 323 34 (w. 0·5) | 21·74 (w. 0·3) |
| (New) D | 15·5 | Blueish | A D 193 48 (w. 0·4) | 80·95 (w. 0·2) |
| (New) E | 17 | Blueish | A E 355 52 (w. 0·2) | 127·30 (?) |
| (New) F | 18 | Blueish | A F 308 52 (w. 0·2) | 106·10 (?) |

Date of observation = 1862·74.

The stars A and B having been described as "in a barren field" when looked at with a good 6-inch object-glass, I turned the Elchies telescope to them, and immediately saw C also; but this star had been previously discovered by Sir John Herschel with his 20-foot reflecting telescope, as mentioned in the "Cycle." A little further attention, however, soon revealed the additional stars D, E, and F, which, as far as I yet know, are new.

The position and distance of A and B, given above, differ from those of the "Cycle" beyond the limits of error of observation, and merit attention therefore; the numbers being

| Position. | Distance. | Date. |
|---|---|---|
| 95°·0 (w. 1) | 15″·0 (w. 1) | 1838·66 |

Elchies new (?) R.A. $21^h\,47^m\,46^s$, and Decl. + 19° 2′ 53″ nearly, Jan. 1, 1862.

| Components. | Mags. | Colours. | Position. | Distance. |
|---|---|---|---|---|
| | | | ° ′ | ″ |
| A | 6·7 | Yellow | | |
| B | 8·7 | Lilac | A B 110 58 (w. 2·0) | 22·26 (w. 1·0) |

Date of observation = 1862·73.

This pair of stars was picked up accidentally, by its coming into the 5-foot finder of the Elchies grand telescope, when the star "312 *Pegasi*" had passed out, through the weights of the driving clock having run down. I have not yet met with any observations of this double star elsewhere; but my references at the present moment are limited, and it seems too bright and too conspicuous for contrasted colours to have escaped many previous observers.*

$\psi'$ Piscium, R.A. $0^h\ 58^m\ 17^s$, and Decl. $+\ 20°\ 44'\ 1''$, Jan. 1, 1862.

| Components. | Mags. | Colours. | Position. | Distance. |
|---|---|---|---|---|
| | | | ° ′ | ″ |
| A | 5 | Yellowish white | | |
| B | 5·5 | Blueish white | A B 160 22 (w. 2·0) | 30·17 (w. 2·0) |
| C | 12·5 | Blueish | A C 121 20 (w. 1·0) | 97·33 (w. 1·0) |

Date of observation = 1862·72.

The existence of C was noted in the "Cycle" as "a very small star following;" but it was not micrometrically observed.

The measures there recorded of A and B are considered "to show *fixity*:" but if the present determination can be trusted to within a very small quantity, an extremely slow orbital movement may rather be inferred; the whole of the previous measures standing thus:—

| | Position. | Distance. | Date. |
|---|---|---|---|
| | ° ′ | ″ | |
| $\frac{H}{W}$ | 170 0 | 27·50 | 1779·83 |
| H and S | 161 2 | 30·34 | 1822·38 |
| Sm. | 160 24 (w. 8) | 30·2 (w. 8) | 1833·97 |

The mags. and colours, given in the "Cycle" as "both 5·5 mag., silvery white," indicate little relative change in these respects during the last twenty-eight years.

222 Arietis, R.A. $1^h\ 51^m\ 56^s$, and Decl. $+\ 20°\ 23'\ 14''$, Jan. 1, 1862.

| Components. | Mags. | Colours. | Position. | Distance. |
|---|---|---|---|---|
| | | | ° ′ | ″ |
| A | 0 | 0 | | |
| B | 12 | Blueish | A B (w. 1·0) | (w. 1·0) |
| C | 12 | Blueish | B C 169 15 (w. 0·5) | 36·94 (w. 0·3) |
| D | 7·5 | Faint yellowish | B D 0 35 (w. 0·5) | 180·44 (w. 0·3) |

Date of observation = 1862·74.

The observation of this group gave me great trouble and

* This star appears to be identical with No. 2841 of Struve's great Catalogue (*Mensuræ Micrometricæ*, p. 188).—R. G.

perplexity, until at last, by successive trials, I became perfectly confident of freedom from clouds, and the absolute R.A. and D. in the field of the telescope, and then recognised that every member of the group was present, except its brightest and leading component; viz. A, which the "Cycle" puts down as of the 6th mag.; while B and C and D are entered of the 15th, 10th, and 9th respectively!

Since the year 1834, therefore, D has increased considerably, and B somewhat; while C has slightly decreased, and A gone out altogether, or at least so far as the great Elchies telescope can penetrate into space! Yet perhaps the most immediately important circumstance of the whole case for practical astronomers is, that it has been said of the group, "It forms an admirable test to try the light and distinctness of a telescope."

The "Cycle" positions and distances to compare with the above are,

| | Position. | Distance. | Date. |
|---|---|---|---|
| | ° ′ | ″ | |
| A B | 53 0 (w. 1) | 2·5 (w. 1) | 1834·99. |
| A C | 165 0 (w. 2) | 40·0 (w. 1) | |
| A D | 359 12 (w. 2) | 165·0 (w. 2) | |

γ Andromedæ, R.A. $1^h\ 55^m\ 25^s$, and Decl. + 41° 40′ 3″,
Jan. 1, 1862.

| Components. | Mags. | Colours. | Position. | Distance. |
|---|---|---|---|---|
| | | | ° ′ | ″ |
| A | 3·5 | Orange yellow | | |
| B | 5·5 | Blueish green | A B C 62 12 (w. 2·0) | 9·73 (w. 0·3) |
| C | 6·0 | Blueish green | B C 116 23 (w. 1·0) | 0·57 (w. 0·3) |

Diameter of disk of B = 0″·37
,, ,, C = 0·23
,, ,, wire = 0·58

Date of observation = 1862·71.

The above observations were procured in the early morning, about sunrise, on one of the only two occasions during the week when I had the fortune to witness, for a few minutes each time, a cessation of those atmospheric disturbances on which the definition of stars seen in a good telescope so greatly depends. The disks of the two close stars were then completely and more than separated, and were so small as to be in diameter only about half the apparent thickness of the fine spider's line of the micrometer employed in the measures.

### *Concluding Notes on the Observations.*

The preceding observations have been hastily arranged, while on the road, so as to represent at one view the results, generally of two and sometimes of three nights' observation of each object. In affixing *weights* to the observations, while following my Father's method, as explained in his "Cycle," and keeping to his upper limit of 10, I have been obliged to descend below his lower limit of 1, by using tenths. This was because the atmospheric perturbations of telescopic definition on the banks of the Spey were really so fearful, and at almost every observation, that, had it not been my first, and too probably my last, opportunity of looking into the Elchies telescope, and therewith examining some anomalous features noted when gazing at certain double stars on the Peak of Teneriffe in 1856, and which I have had no other opportunity of inquiring into, I should not have made any observations at all, but have waited for a more favourable condition of the atmosphere.

By assigning such small weights as I have done, I hope to avoid doing any harm by otherwise sending out inferior, to mix, uncorrected, with superior observations by other and abler hands; while, with some of the objects, the cosmical changes have been so rapid, or the powers of the telescope so transcendent, as to overbear the rudeness of my micrometer-measures, and to show some valuable additions to the many physical facts recorded in the "Cycle" up to its closing epoch. That book is the only one I have yet compared the observations with, and the only one I have with me on the journey; but I trust that I shall be allowed more honourable reasons also, for desiring to use it as a standard work of reference.

The value of the micrometer-screw in seconds of space has as yet only been approximately determined from the observations made for the purpose, and may, perhaps, require a small addition, as of about $\frac{1}{200}$ of the whole; but that present uncertainty on the distances alone, will not at all interfere with the character of the chief results now brought out, as affecting the discovery of new stars and changes in angle of position of old stars, or large variation in their distances.

Illumination of the field, and by red light, according to Sir John Herschel's discriminating suggestion, was always employed for the actual micrometer-measures; but the estimation of magnitudes and colours was always made in a darkened field.

*Oban, October 7th*, 1862.

*Extract of a Letter from Dr. Wolfers to the Rev. R. Main, dated Berlin, October 31, 1862.*

The xxth volume of the *Radcliffe Observations*, presented to me by the Radcliffe Trustees, came into my hands some time ago, and I have compared the places of the fundamental stars contained in that volume with those contained in the *Tabulæ Reductionum*. In this manner I have formed the two tables, A and B, belonging respectively to the years 1859 and 1860. There are some differences between observation and calculation (F.—W.), which are too great to be attributed to errors of observation. It is possible that there is an error committed in the reduction of the observations, wherefore I have included in [the] differences in question. These being excepted, I have combined the two series of differences with the series obtained in the year 1861, and published in the *Monthly Notices*, vol. xxii. No. 2, p. 31. In this manner I have obtained the table designated by the letter C.

Excluding now the R.A. of the circumpolar stars *α* and *γ Ursæ Majoris*, *α*, *β*, and *δ Ursæ Minoris*, and of *α Geminorum* (the latter for a reason previously given), the result of the comparison is the following:—

| Number of Observations. | F.—W. in R.A. | Number of Observations. | F.—W. in Decl. |
|---|---|---|---|
| | s | | ″ |
| 448 | +0·110 | 307 | +0·032 |

This result being compared with the result of the preceding year, viz.

| Number of Observations. | F.—W. in R.A. | Number of Observations. | F.—W. in Decl. |
|---|---|---|---|
| | s | | ″ |
| 326 | +0·017 | 288 | +0·046 |

it is evident that, as the number of observations is increased, the mean difference of the two co-ordinates is diminished. These values belong to January 1, 1860.

## A.

*Right Ascensions and Declinations of Fundamental Stars observed at the Radcliffe Observatory in the Year 1859, compared with those contained in the Tabulæ Reductionum.*

| Name of Star. | Number of Observations. | F.—W. R.A. | Number of Observations. | F.—W. Decl. |
|---|---|---|---|---|
| | | s | | ″ |
| *α* Andromedæ | 1 | 0·00 | | |
| *γ* Pegasi | 3 | −0·11 | | |
| *α* Arietis | 1 | −0·01 | | |
| *α* Ceti | 1 | +0·08 | | |
| *α* Geminorum | | | 1 | +2·0 |

| Name of Star. | Number of Observations. | F.—W. R.A. | Number of Observations. | F.—W. Decl. |
|---|---|---|---|---|
| | | s | | ″ |
| α Canis Minoris | 1 | [+0·15] | 1 | −1·2 |
| β Geminorum | 1 | −0·04 | | |
| α Hydræ | 3 | −0·02 | | |
| α Leonis | 1 | 0·00 | | |
| β Leonis | 1 | +0·05 | | |
| α Virginis | 3 | 0·00 | 1 | −0·1 |
| η Ursæ Majoris | | | 1 | −2·7 |
| α Böotis | 1 | +0·01 | | |
| α Coronæ | 1 | −0·02 | | |
| α Serpentis | 1 | −0·04 | | |
| α Herculis | 1 | 0·00 | | |
| α Ophiuchi | 4 | −0·02 | 1 | −0·3 |
| $\alpha^1$ Capricorni | 1 | +0·07 | | |
| α Cygni | 2 | −0·04 | | |
| α Aquarii | 5 | −0·03 | 1 | −0·3 |

## B.

*Right Ascensions and Declinations of Fundamental Stars, observed at the Radcliffe Observatory in the Year* 1860, *compared with those contained in the Tabulæ Reductionum.*

| Name of Star. | Number of Observations. | F.—W. R.A. | Number of Observations. | F.—W. Decl. |
|---|---|---|---|---|
| | | s | | ″ |
| α Andromedæ | 2 | [−0·13] | | |
| γ Pegasi | 3 | [−0·20] | | |
| α Arietis | 5 | −0·02 | 1 | +2·8 |
| α Ceti | 4 | −0·05 | | |
| α Tauri | 1 | [−0·27] | | |
| β Leonis | 1 | +0·05 | | |
| β Virginis | 2 | +0·11 | | |
| γ Ursæ Majoris | 1 | [+0·41] | | |
| η Ursæ Majoris | 4 | [+0·18] | | |
| α Böotis | 1 | [−0·38] | | |
| $\alpha^2$ Libræ | 1 | +0·06 | | |
| β Ursæ Minoris | | | 1 | −2·2 |
| α Serpentis | 1 | +0·11 | | |
| α Scorpii | 1 | [−0·28] | | |
| α Herculis | 2 | −0·07 | | |
| α Ophiuchi | 4 | −0·04 | | |
| γ Draconis | 4 | +0·12 | | |
| α Lyræ | 2 | −0·03 | | |
| γ Aquilæ | 9 | −0·10 | 3 | −0·6 |

| Name of Star. | Number of Observations. | F.—W. R.A. s | Number of Observations. | F.—W. Decl. ″ |
|---|---|---|---|---|
| α Aquilæ | 9 | −0·01 | | |
| β Aquilæ | 11 | +0·03 | 2 | −2·0 |
| $\alpha^2$ Capricorni | 2 | +0·13 | | |
| α Cygni | 14 | −0·07 | | |
| α Cephei | 5 | [+0·37] | 1 | +0·7 |
| β Cephei | | | 4 | [−4·6] |
| α Aquarii | 9 | −0·06 | | |
| α Piscis Austrini | 1 | −0·01 | | |
| α Pegasi | 10 | +0·02 | 1 | −2·0 |
| α Ursæ Minoris | 6 | −0·15 | 3 | +0·8 |
| δ Ursæ Minoris | | | 1 | +1·5 |

## C.

*Right Ascensions and Declinations of Fundamental Stars observed at the Radcliffe Observatory in the Year* 1861, *compared with those contained in the Tabulæ Reductionum.*

| Name of Star. | Number of Observations. | F.—W. R.A. s | Number of Observations. | F.—W. Decl. ″ |
|---|---|---|---|---|
| α Andromedæ | 5 | +0·02 | 5 | +0·7 |
| γ Pegasi | 12 | −0·06 | 6 | +2·6 |
| α Cassiopeiæ | 3 | +0·09 | 4 | −0·4 |
| α Arietis | 12 | −0·02 | 4 | +1·8 |
| α Ceti | 14 | 0·00 | 4 | +0·4 |
| α Persei | 5 | −0·06 | 3 | −0·2 |
| α Tauri | 16 | −0·02 | 9 | +0·2 |
| α Aurigæ | 5 | −0·01 | 6 | −0·6 |
| β Orionis | 8 | 0·00 | 7 | +0·4 |
| β Tauri | 5 | +0·05 | 6 | +2·5 |
| α Orionis | 8 | +0·02 | 5 | +1·4 |
| α Canis Majoris | 8 | −0·02 | 20 | −0·4 |
| α Geminorum | 10 | +0·12 | 9 | +1·8 |
| α Canis Minoris | 11 | +0·03 | 10 | +0·4 |
| β Geminorum | 17 | −0·01 | 10 | +0·3 |
| α Hydræ | 12 | +0·04 | 7 | −2·1 |
| α Leonis | 16 | +0·01 | 12 | +1·1 |
| α Ursæ Majoris | 5 | +0·32 | 12 | +0·6 |
| β Leonis | 11 | +0·07 | 6 | −0·3 |
| β Virginis | 11 | +0·12 | 5 | −0·4 |
| γ Ursæ Majoris | 5 | +0·21 | 2 | +0·2 |
| α Virginis | 15 | +0·06 | 15 | −1·2 |
| η Ursæ Majoris | 10 | +0·06 | 3 | −1·4 |
| α Böotis | 7 | +0·02 | 2 | +0·4 |

| Name of Star. | Number of Observations. | F.—W. R.A. | Number of Observations. | F.—W. Decl. |
|---|---|---|---|---|
| | | s | | " |
| $\alpha^1$ Libræ | 1 | +0·04 | 5 | −0·4 |
| $\alpha^2$ Libræ | 11 | +0·10 | 3 | −0·6 |
| β Ursæ Minoris | 1 | −0·26 | 6 | −0·5 |
| α Coronæ | 10 | +0·01 | 3 | −0·7 |
| α Serpentis | 12 | +0·01 | 3 | −0·4 |
| α Scorpii | 12 | +0·14 | 7 | −0·2 |
| α Herculis | 9 | −0·08 | 1 | −0·2 |
| α Ophiuchi | 18 | −0·02 | 9 | −0·1 |
| γ Draconis | 9 | +0·07 | 4 | −0·8 |
| α Lyræ | 13 | +0·05 | 8 | −0·4 |
| γ Aquilæ | 15 | −0·06 | 6 | −0·7 |
| α Aquilæ | 19 | −0·03 | 9 | +0·3 |
| β Aquilæ | 15 | +0·03 | 6 | −0·5 |
| $\alpha^1$ Capricorni | 1 | +0·07 | 2 | −1·8 |
| $\alpha^2$ Capricorni | 7 | +0·04 | 5 | −2·8 |
| α Cygni | 24 | −0·05 | 6 | −2·4 |
| α Cephei | 11 | −0·07 | 8 | +0·9 |
| β Cephei | 4 | −0·11 | 10 | +0·2 |
| α Aquarii | 23 | −0·05 | 3 | −0·8 |
| α Piscis Austrini | 9 | −0·02 | 8 | −0·4 |
| α Pegasi | 14 | −0·02 | 7 | −0·5 |
| α Ursæ Minoris | 14 | −0·20 | 7 | +0·3 |
| δ Ursæ Minoris | 4 | +0·48 | 10 | +1·8 |

[*Note by Mr. Main.* Of the anomalous results in R.A., referred to by Dr. Wolfers, I may state that the R.A. of *Arcturus*, included in the Catalogue of Stars for 1860, should be rejected, as the number of determining clock-stars is too small. It has crept in by inadvertence. In addition to this, there must have been something singularly wrong in the observation, as will be immediately seen by comparing the clock-error given by it with that given by η *Böotis* (Nov. 21). Of the rest, the R.A.'s of *Aldebaran*, *Procyon*, γ *Ursæ Majoris*, and *Antares*, depend on single observations.

The anomalous cases occurring in 1860, October 11 and November 21, had been scrutinised before the observations passed the press; and the anomalies are due to strange errors in the observations, not to errors in the reductions.

In future years much better means will be given for the continuation of Dr. Wolfers' researches on the places of the fundamental stars, as clock-errors are determined by the same list of stars as that used at Greenwich, and the assumed equinox will be identical with the Greenwich assumed equinox.]

For the following abstract of Mr. Auwers' paper, On the Irregularities of the Motion of *Procyon*, and on the Determination of the Elements of an obscure Companion of *Procyon*, the attraction of which will explain these irregularities, the Society and myself are indebted to W. T. Lynn, Esq., Assistant of the Royal Observatory of Greenwich.

It may be necessary to correct a misunderstanding that might possibly be produced in the minds of some readers by the expressions of the first paragraph. The irregularities in the annual motions of stars generally, and of *Procyon* in particular, were first pointed out by Mr. Pond. In the *Greenwich Observations*, 1820–22, is a Table of "Right Ascensions of the 36 Stars of the Greenwich Catalogue, reduced to the beginning of the year 1819, from five years' observations with the new Transit Instrument, 1817–1821, and compared with Dr. Maskelyne's Catalogue of the year 1805 brought up to the same period;" the principal discordances are those of $\alpha^2$ *Capricorni*, *Sirius*, *Spica*, *Procyon*. In the *Greenwich Observations*, 1825, is "A Table showing the difference between the predicted and observed N.P.D. of 45 principal fixed stars for the year 1826;" the principal discordances are those of $\alpha$ *Pegasi*, $\gamma$ *Aquilæ*, *Sirius*, *Procyon*. In the *Philosophical Transactions*, 1823, page 36, Mr. Pond says, "A very great deviation in N.P.D. will be found in three very bright stars, *Capella*, *Procyon*, and *Sirius;*" in page 44 he again specifies *Procyon* and *Sirius*, and in page 529, he speaks of the impossibility of exactly interpolating or predicting a star's place. Finally, in the Introduction to the Catalogue of 1112 stars, dated June 27, 1833, he says, "We can hardly desire a better test of our power of predicting the future position of the stars, than by trying by the same formulæ how accurately we can interpolate for the past. In a variety of papers, which I have submitted at times to the Royal Society, I have endeavoured to show that *with us* the latter experiment entirely fails."

G. B. Airy.

*Abstract of the Paper by Auwers on the Proper Motion of Procyon, contained in Nos.* 1371, 1372, *and* 1373, *of the Astronomische Nachrichten.*

In this paper Auwers first gives the history of the investigations made into the proper motions of *Sirius* and *Procyon* thus: Bessel discovered in 1844 that the observed Right Ascensions of *Sirius* and Declinations of *Procyon* negatived the existence of an invariable Proper Motion of those stars, and showed that its variability was to be explained by the attraction of bodies connected with them, and forming thereby binary systems, the remaining components of which were not perceptible to us, or at least had not hitherto been perceived. Doubt was on various sides thrown upon this result, new,

surprising, and founded as it was upon very small quantities, measurable only by means of very frequently repeated observations, until Peters in 1851 demonstrated that the irregularities in the observed Right Ascensions of *Sirius* were such that they could be completely explained by the assumption of a periodical motion about a neighbouring point, itself in uniform motion; further proof of this explanation has since been afforded by investigation of the observed Declinations of that star. The argument for the existence of a similar variability in the Proper Motion of *Procyon* was greatly increased when Mädler in 1851 showed that irregularities were evidenced in its observed Right Ascensions as well as Declinations. Up to the present time, however, the question, as regards *Procyon*, has been considered an open one; Auwers, therefore, last year (1861) undertook and executed a new investigation of it, the principal features of which are contained in the paper before us, and the result of which has completely, he tells us, confirmed Bessel's hypothesis.

In this investigation he has made use of all the available published observations of *Procyon* from 1750 to 1860, using for stars of comparison in R.A. *α Tauri*, *β*, *α Orionis*, *β Geminorum*, *α Hydræ*, and *α Leonis*; and in N.P.D. *α Ceti*, *α Orionis*, *α Serpentis*, *γ*, *α*, *β Aquilæ*, and *α Aquarii*. The latter list agrees with Bessel's, save that Auwers has omitted *β Virginis*, because it has only exceptionally been observed at the English Observatories. The comparison is effected by comparing the observed place of each star with its computed place in the *Tabulæ Regiomontanæ*. After giving several tables of the results obtained from observations during the above-mentioned times, made principally at Greenwich (Bradley, Maskelyne, Pond, and Airy), Königsberg, Edinburgh, Oxford, Cambridge, Geneva, and Washington, he remarks that inspection alone is sufficient to prove the certainty of changes in the Proper Motion, and therefore he need only occupy himself with the question whether these changes are capable of being explained by the assumption of a motion in a binary system. And he finds that the irregularities are of the nature that they may be explained by the assumption of a circular motion of *Procyon*, in a plane perpendicular to the line of sight, round a point about $1''\cdot2$ distant. After trying this assumption and correcting it according to the method of least squares, he at last forms the following set of elements of the motion of *Procyon*:—

| | | Probable Error. |
|---|---|---|
| Epoch of Minimum R.A. | $= 1795\cdot5676$ | $\pm 0^{y}\cdot4457$ |
| Yearly Motion | $= 9^{\circ}\cdot00634$ | $0^{\circ}\cdot09110$ |
| Periodic Time | $= 39^{y}\cdot972$ | $0^{y}\cdot4043$ |
| Radius of Orbit | $= 1''\cdot0525$ | $0''\cdot0275$ |

Then follows a Table containing a comparison of these ex-

pressions with observations, which shows "that the representation of the latter by the elements is perfectly satisfactory," there being no remarkable deviation in any part of the orbit, but the differences from observation having the character of being fortuitous, and following no law.

In order to be able to assign a limit to the mass of the invisible companion of *Procyon*, he has deduced a provisional approximate value of the parallax of that star from a series of observations with the Königsberg heliometer, not originally commenced with any view to such a determination. He has thus obtained for that parallax the value 0″·123, with the probable error ± 0″·033; "with this number," he says, "we should find from the above elements that the mass of the dark body must be greater than 0·4 that of the Sun. We may assume with certainty that the parallax of *Procyon* is less than 0″·2; in any case therefore the dark body must have a mass at least a hundred times as great as that of *Jupiter*. If *Procyon* and its companion have equal masses, that of each must be greater than 0·37 that of the Sun, and if the mass of *Procyon* is equal to that of the Sun, that of its companion must be greater than 0·6 that of the Sun."

The paper concludes with a table of the corrections to be applied according to this theory to the Right Ascensions and Declinations of *Procyon* in the *Tabulæ Reductionum* from the year 1750 to 1880.

W. T. L.

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## *Rule for the Solution of Kepler's Problem.*

By M. de Gasparis.

(*Communicated by the President.*)

Exemple. Soit $M = 27^\circ\,12'\,33''{\cdot}62 = E - (9{\cdot}8947213)\sin E$.

Je pose $A = 9{\cdot}3471561$, qui s'obtient en otant log. $e$ du nombre 9·2418774, qui est le logarithme de 10° en parties du rayon.

Après cela l'on prend les $\log \frac{\sin(M+10^\circ)}{1}$, $\log \frac{\sin(M+20^\circ)}{2}$, $\log \frac{\sin(M+30^\circ)}{3}$, etc., et l'on s'arrête lorsque le résultat est proximément $> A$.

Le but de cette opération est d'approcher E à 10° près. Il suffit donc d'envisager les premiers chiffres, et pourvu que l'on sache les premiers chiffres des logarithmes des nombres simples,

l'opération se fait à vue d'œil. L'on trouve E =67° 12′ à 10° près. Et E−M= ✱ 4 dixaines de degré. L'on poursuit ainsi

| | |
|---|---|
| Log sin 67° 12′=9·965 | Log 77° 12′=9·989 |
| Log ✱ 4=0·602 | Log 5=0·699 |
| 9·363 | 9·290 |

Maintenant pour 73 différence entre ces deux derniers logarithmes, la variation de E est 10×1°; pour 16, différence entre 9·363 et A, la variation de E est ✱ 2×1°=2°. Donc E=69° 12′ à 1° près.

| | |
|---|---|
| Log sin 69° 12′=9·9707 | Log sin 70° 12′=9·9735 |
| Log ✱ 42=1·6233 | Log 43=1·6335 |
| 8·3474 | 8·3400 |

74 : 10×6′ :: 3 : ✱ 0×6′=0′ Donc E=69° 12′ à 6′ près,

ici l'on a pris la différence de 8·3474 avec A−1.

| | |
|---|---|
| Log sin 69° 12′ 30″=9·97075 | Log 69° 18′ 30″=9·97104 |
| Log ✱ 420=2·62325 | Log 421=2·62428 |
| 7·34750 | 7·34676 |

74 : 10×36″ :: 34 : ✱ 4×36″=2′24″ Donc E=69° 14′ 54″ à 36″ près,

ici l'on a pris la différence de 7·34750 avec A−2, et l'on a pris le log sin 69° 12′ 30″ au lieu de log sin 69° 12′ pour tenir compte des secondes comprises dans M.

L'on doit remarquer que l'on a approché E à 36″ sans avoir du tenir compte des parties proportionnelles des logarithmes pris dans les tables. On pourrait dire de même jusqu'à l'approximation à 3″·6.

| | |
|---|---|
| Log sin 69° 14′ 57″=9·970872 | Log sin 69° 15′ 33″=9·970900 |
| Log ✱ 4204=3·623663 | Log 4205=3·623766 |
| 6·347209 | 6·347134 |

75 : 10×3″·6 :: 53 : ✱ 7×3″·6=25″·2 Donc E=69°15′22″·2 à 3″·6 près.

* It is to be noticed that the proportions which give the numbers which the author has thus marked, with an asterisk, depending on a multiplication by 10, and a division where the quotient is taken to a single figure only, are solved at sight. — Ed.

| | |
|---|---|
| Log sin 69°15′22″·82 = 9·9708926 | Log sin 69°15′26″·42 = 9·9708955 |
| Log ∗ 42047 = 4·6237350 | Log 42048 = 5·6237453 |
| 5·3471576 | 4·3471502 |
| 74 : 10 × 0″·36 :: 15 : ∗ 2 × 0″·36 = 0″·72 | E = 69°15′23″·54 à 0″·36 près. |
| Log sin 69°15′23″·54 = 9·9708932 | Log sin 69°15′23″·90 = 9·9708935 |
| Log 420472 = 5·6237371 | Log 420473 = 5·6237381 |
| 4·3471561 | 4·3471554 |
| 7 : 10 × 0″·036 :: 0 : ∗ 0 × 0″·036 = 0 | E = 69°15′23″·54 à 0″·01 près. |

Pour les grandes excentricités la différence, qui dans cet exemple est 74, est proximément constante. Cela peut servir pour controle dans les calculations.

Enfin, il est plus long d'expliquer cette règle, que de la mettre en pratique.

*Naples*, 21 *Mai*, 1862.

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*Observations of the Planet Neptune, made with the Olcott Meridian Circle, at the Dudley Observatory, Albany, U.S.A.* By G. W. Hough, Assistant.

(*Communicated by Prof. Mitchell through the Astronomer Royal*).

| 1862. | M.T. Dudley Observatory. h m s | App. R.A. h m s | App. Decl. ° ′ ″ |
|---|---|---|---|
| Sept. 24 | 11 46 54·61 | ..... | −1 13 44·76 |
| 25 | 11 42 52·65 | 0 2 45·70 | 1 14 25·34 |
| 28 | 11 30 46·79 | 0 2 27·51 | 1 16 25·03 |
| Oct. 3 | 11 10 37·29 | 0 1 57·46 | 1 19 41·17 |
| 8 | 10 50 28·42 | 0 1 28·05 | 1 22 51·17 |
| 9 | 10 46 26·66 | 0 1 22·18 | |
| 14 | 10 26 18·78 | 0 0 53·76 | 1 26 29·20 |
| 28 | 9 30 4·42 | 23 59 41·92 | 1 33 59·68 |
| 29 | 9 26 3·94 | 23 59 37·34 | 1 34 27·89 |
| Nov. 18 | 8 6 12·93 | 23 58 24·31 | 1 41 45·60 |
| 19 | 8 2 14·52 | 23 58 21·81 | 1 42 0·50 |
| 22 | 7 50 19·74 | 23 58 14·74 | 1 42 38·27 |
| 25 | 7 38 25·94 | 23 58 8·67 | 1 43 10·80 |
| 26 | 7 34 28·37 | 23 58 7·0 | 1 43 20·93 |
| 30 | 7 18 38·92 | 23 58 1·18 | 1 43 46·47 |
| Dec. 2 | 7 10 44·88 | 23 57 58·96 | 1 43 56·49 |
| 3 | 7 6 48·04 | 23 57 58·02 | 1 43 58·16 |
| 14 | 6 23 31·28 | 23 57 56·39 | 1 43 42·84 |
| 17 | 6 11 45·83 | 23 57 58·59 | 1 43 20·11 |
| 18 | 6 7 50·91 | 23 57 59·59 | 1 43 11·63 |
| 21 | 5 56 6·92 | 23 58 3·34 | 1 42 37·10 |
| 24 | 5 44 24·05 | 23 58 8·21 | 1 41 59·02 |
| 30 | 5 21 1·61 | 23 58 21·28 | −1 40 17·91 |

| Date. | R.A. Correction to Amer. Eph. | R.A. Correction to Naut. Alm. | N.P.D. Correction to Amer. Eph. | N.P.D. Correction to Naut. Alm. |
|---|---|---|---|---|
| 1861. | s | s | ″ | ″ |
| Sept. 24 | ... | ... | +10·41 | +4·98 |
| 25 | −1·63 | −0·81 | 11·09 | 5·68 |
| 28 | 1·60 | 0·80 | 11·68 | 6·23 |
| Oct. 3 | 1·56 | 0·78 | 12·23 | 6·76 |
| 8 | 1·50 | 0·71 | 11·97 | 6·43 |
| 9 | 1·57 | 0·79 | | |
| 14 | 1·63 | 0·88 | 11·40 | 6·17 |
| 28 | 1·56 | 0·81 | 9·94 | 4·52 |
| 29 | 1·53 | 0·78 | 9·64 | 4·23 |
| Nov. 18 | 1·53 | 0·84 | 10·40 | 5·41 |
| 19 | 1·47 | 0·78 | 10·80 | 5·87 |
| 22 | 1·52 | 0·81 | 9·73 | 4·89 |
| 25 | 1·59 | 0·89 | 10·44 | 5·61 |
| 26 | 1·50 | 0·81 | 11·57 | 6·71 |
| 30 | 1·48 | 0·79 | 9·11 | 4·20 |
| Dec. 2 | 1·51 | 0·82 | 10·00 | 5·09 |
| 3 | 1·54 | 0·82 | 8·36 | 3·53 |
| 14 | 1·49 | 0·85 | 11·14 | 6·47 |
| 17 | 1·50 | 0·85 | 10·93 | 6·13 |
| 18 | 1·49 | 0·85 | 11·53 | 6·74 |
| 21 | 1·48 | 0·86 | 9·30 | 4·60 |
| 24 | 1·47 | 0·87 | 10·80 | 6·13 |
| 30 | −1·51 | −0·91 | +10·83 | +6·11 |

| | R.A. Mean Correction to Amer Eph. | R.A. Mean Correction to Naut. Alm. | N.P.D. Mean Correction to Amer. Eph. | N.P.D. Mean Correction to Naut. Alm. |
|---|---|---|---|---|
| | s | s | ″ | ″ |
| Sept. and Oct. | −1·57 | −0·79 | +11·04 | +5·63 |
| Nov. | −1·52 | −0·82 | +10·17 | +5·45 |
| Dec. | −1·50 | −0·85 | +10·36 | +5·60 |
| Mean Day. | | | | |
| Nov. 17 | −1·529 | −0·824 | +10·52 | +5·56 |

From these results it is readily seen that neither Ephemeris represents the motion of the planet correctly in R.A. The variation for 100 days is $+0^{s}\cdot109$ for the American Ephemeris, and $-0^{s}\cdot087$ for the *Nautical Almanac*. By applying the variation, the probable error for a single observation is $0^{s}\cdot029$ for the American Ephemeris, and $0^{s}\cdot025$ for the *Nautical Almanac*.

In Declination the probable errors are $0''\cdot80$ and $0''\cdot79$. The transits on October 28th, November 19th, and December 2d, were observed on 9, 10, and 7 wires respectively. In all the other observations 15 wires were used, and the times of transit recorded in on the Chronograph. Any change in the rate of the Clock (during the time of observation) was satis-

factorily determined by comparison with two other Clocks, by causing their pendulums to make records on the Chronograph at intervals of 30 minutes.

In converting the chronographic records into time, every wire was measured to the hundredth of a second. But in the "mean" and all subsequent reductions the thousandths were retained, being rejected in the final result only.

N.B. The observations published in the *Monthly Notices*, vol. xxii., No. 1, pages 18 and 19, were not corrected for parallax.

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## *Results of the Meridional Observations of Small Planets; Occultations of Stars by the Moon; and Transit of Jupiter's Third Satellite; observed at the Royal Observatory, Greenwich, from June to September*, 1862.

(*Communicated by the Astronomer Royal.*)

### *Hebe* (6).

| Mean Solar Time of Observation. | R.A. from Observation. | N.P.D. from Observation. |
|---|---|---|
| | h m s | ° ′ ″ |
| 1862, June 14 | 10 57 12·3 | 16 29 6·40 | 90 4 8·51 |
| 16 | 10 47 32·6 | 16 27 18·25 | 90 9 8·15 |
| 27 | 9 55 27·9 | 16 18 27·14 | 90 51 1·69 |
| 28 | 9 50 50·7 | 16 17 45·68 | 90 55 57·26 |
| July 2 | 9 32 34·3 | 16 15 12·55 | 91 17 34·97 |

### *Iris* (7).

| Mean Solar Time of Observation. | R.A. from Observation. | N.P.D. from Observation. |
|---|---|---|
| | h m s | ° ′ ″ |
| 1862, Aug. 18 | 13 33 11·0 | 23 21 26·92 | 83 8 41·41 |
| 19 | 13 28 43·3 | 23 21 15·01 | 83 8 2·01 |
| 27 | 12 52 6·6 | 23 16 4·78 | 83 11 48·47 |
| 28 | 12 47 26·2 | 23 15 20·15 | 83 13 28·23 |
| Sept. 3 | 12 19 3·5 | 23 10 32·15 | 83 28 30·87 |
| 10 | 11 45 29·2 | 23 4 28·13 | 83 56 38·05 |
| 11 | 11 40 40·6 | 23 3 35·32 | 84 1 28·79 |
| 16 | 11 16 39·9 | 22 59 13·45 | 84 28 14·24 |
| 17 | 11 11 52·9 | 22 58 22·24 | 84 34 1·23 |
| 19 | 11 2 20·9 | 22 56 41·71 | 84 46 0·53 |
| 22 | 10 48 18·9 | 22 54 17·04 | 85 4 48·02 |
| 23 | 10 43 26·8 | 22 53 30·75 | 85 11 12·95 |
| 25 | 10 34 6·3 | 22 52 1·86 | 85 24 12·32 |

## *Parthenope* (11).

| Mean Solar Time of Observation. | h m s | R.A. from Observation. h m s | N.P.D. from Observation. ° ′ ″ |
|---|---|---|---|
| 1862, July 12 | 13 14 56·0 | 20 37 36·38 | 107 42 16·40 |
| 19 | 12 41 44·7 | 20 31 55·46 | 108 22 12·61 |
| 25 | 12 12 50·4 | 20 26 35·74 | 108 58 3·46 |
| 26 | 12 8 0·1 | 20 25 41·28 | 109 4 5·79 |
| 31 | 11 43 49·0 | 20 21 8·92 | 109 33 48·05 |
| Aug. 14 | 10 37 20·2 | 20 9 41·02 | 110 49 0·21 |
| 25 | 9 47 58·0 | 20 3 32·82 | 111 34 16·79 |
| 29 | 9 30 52·9 | 20 2 11·12 | 111 46 55·66 |

## *Egeria* (18).

| Mean Solar Time of Observation. | h m s | R.A. from Observation. h m s | N.P.D. from Observation. ° ′ ″ |
|---|---|---|---|
| 1862, Sept. 3 | 13 13 57·2 | 0 5 34·78 | 112 56 10·43 |
| 16 | 12 9 59·9 | 23 52 42·22 | 113 39 0·57 |
| 22 | 11 40 10·8 | 23 46 27·48 | 113 46 56·83 |

## *Melpomene* (18).

| Mean Solar Time of Observation. | h m s | R.A. from Observation. h m s | N.P.D. from Observation. ° ′ ″ |
|---|---|---|---|
| 1862, June 4 | 9 45 33·4 | 14 37 50·13 | 89 43 58·59 |

## *Pomona* (32).

| Mean Solar Time of Observation. | h m s | R.A. from Observation. h m s | N.P.D. from Observation. ° ′ ″ |
|---|---|---|---|
| 1862, Sept. 16 | 12 50 23·2 | 0 33 12·16 | 81 2 57·88 |
| 17 | 12 45 41·7 | 0 32 26·45 | 81 8 50·69 |
| 22 | 12 22 6·3 | 0 28 29·95 | 81 39 31·59 |
| 25 | 12 7 52·5 | 0 26 3·41 | 81 59 10·24 |

## *Lætitia* (39).

| Mean Solar Time of Observation. | h m s | R.A. from Observation. h m s | N.P.D. from Observation. ° ′ ″ |
|---|---|---|---|
| 1862, June 30 | 12 18 37·6 | 18 53 50·02 | 99 6 56·01 |
| July 12 | 11 21 13·5 | 18 43 35·15 | 99 47 53·86 |
| 19 | 10 48 5·8 | 18 37 57·94 | 100 18 55·68 |

*Aglaia* (47).

| Mean Solar Time of Observation. | h m s | R.A. from Observation. h m s | N.P.D. from Observation. ° ′ ″ |
|---|---|---|---|
| 1862, Sept. 22 | 12 48 2·2 | 0 54 30·10 | 83 23 40·08 |

*Doris* (49).

| Mean Solar Time of Observation. | h m s | R.A. from Observation. h m s | N.P.D. from Observation. ° ′ ″ |
|---|---|---|---|
| 1862, July 19 | 12 28 6·5 | 20 18 15·04 | 101 3 11·11 |
| 31 | 11 31 50·3 | 20 9 8·23 | 101 42 25·34 |
| Aug. 7 | 10 59 14·1 | 20 4 2·63 | 102 8 7·76 |
| 19 | 10 4 31·3 | 19 56 29·43 | 102 53 33·09 |
| 22 | 9 51 12·9 | 19 54 58·60 | 103 4 57·07 |
| 25 | 9 37 58·4 | 19 53 31·61 | 103 15 57·14 |

All the observations of N.P.D. are corrected for refraction and parallax.

*Occultations of Stars by the Moon.*

| Day of Obs. | Phenomenon. | Moon's Limb. | Mean Solar Time. h m s | Observer. |
|---|---|---|---|---|
| 1862, July 15 | $\kappa$ Piscium reapp. (*a*) | Dark | 11 25 20·6 | E. |
| 15 | 9 Piscium reapp. (*a*) | Dark | 11 30 22·8 | E. |
| 21 | $\upsilon^1$ Tauri reapp. | Dark | 14 56 59·3 | T. C. |
| Sept. 3 | $\pi$ Sagittarii disapp. | Dark | 11 45 23·2 | C. |

(*a*) Observed through thin cloud; considered true to a second.

The initials E., C., and T. C., are those of Mr. Ellis, Mr. Criswick, and Mr. Chappell.

The egress of *Jupiter's* third Satellite was observed on June 16, by Mr. Ellis, to take place at $10^h\ 22^m\ 17^s\ 2$, M.S.T.

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*Measures of the Planet Mars, made, at the Opposition of* 1862, *with the Heliometer at the Radcliffe Observatory, Oxford, for the Determination of the Ellipticity of the Disk.* By the Rev. R. Main. (Abstract.)

This paper, which is accompanied by eleven drawings of the planet *Mars*, gives the results of eighteen sets of measures made by Mr. Main for the purpose of determining the ellipticity and size of the planet. Each set of observations consists of at least ten measures of the polar, and ten of the equatoreal diameter, and each result is rigorously corrected for defective

illumination of the disk in the direction of each diameter, and for the corresponding effects of refraction.

The results arrived at are as follows :—

| Day, 1862. | Corrected Equatoreal Diameter. | Corrected Polar Diameter. | Ellipticity. | | Equatoreal Diameter at Unit of Distance. |
|---|---|---|---|---|---|
| Sept. 18 | 22".386 | 21".872 | 0·02296 | $\frac{1}{43·55}$ | 9".25 |
| 19 | 22·987 | 22·374 | ·02667 | $\frac{1}{37·50}$ | 9·47 |
| 22 | 22·978 | 22·729 | ·01084 | $\frac{1}{92·28}$ | 9·39 |
| 23 | 22·914 | 22·162 | ·03282 | $\frac{1}{30·47}$ | 9·34 |
| 25 | 23·112 | 22·576 | ·02319 | $\frac{1}{43·12}$ | 9·39 |
| 27 | 23·131 | 22·543 | ·02542 | $\frac{1}{39·34}$ | 9·39 |
| 30 | 23·018 | 22·924 | ·00408 | $\frac{1}{244·87}$ | 9·35 |
| Oct. 8 | 22·674 | 22·208 | ·02055 | $\frac{1}{48·66}$ | 9·38 |
| 9 | 22·780 | 22·314 | ·02046 | $\frac{1}{48·88}$ | 9·46 |
| 11 | 22·564 | 22·230 | ·01480 | $\frac{1}{67·56}$ | 9·45 |
| 15 | 21·734 | 21·385 | ·01606 | $\frac{1}{62·28}$ | 9·31 |
| 16 | 21·668 | 21·296 | ·01717 | $\frac{1}{58·25}$ | 9·34 |
| 17 | 21·699 | 20·938 | ·03507 | $\frac{1}{28·51}$ | 9·42 |
| 18 | 21·495 | 20·828 | ·03103 | $\frac{1}{32·23}$ | 9·39 |
| 20 | 21·034 | 20·775 | ·01231 | $\frac{1}{81·21}$ | 9·33 |
| 22 | 20·830 | 20·419 | ·01973 | $\frac{1}{50·68}$ | 9·39 |
| 23 | 20·774 | 20·267 | ·02556 | $\frac{1}{39·12}$ | 9·44 |
| 26 | 19·942 | 19·389 | ·02773 | $\frac{1}{36·06}$ | 9·31 |
| Means | ..... | ..... | 0·02147 | $\frac{1}{46·58}$ | 9·38 |

The ellipticity requires correction for the depression of the Earth below the plane of the equator of *Mars*. When this correction is applied, the ellipticity is finally $\frac{1}{39·04}$.

The angular diameter at the unit of distance, namely, 9″·38, corresponds to a real diameter of 4332 miles, but this still requires correction for the effect of irradiation. For the determination of the irradiation, Mr. Main proposes to make observations when the disk of *Mars* has become small.

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*Places derived from Observations of Comet II.*, 1862, *made with the Heliometer at the Radcliffe Observatory, Oxford.* By the Rev. R. Main.

| Day, 1862. | Greenwich Mean Solar Time. h m s | Apparent R.A. h m s | Apparent N.P.D. ° ′ ″ |
|---|---|---|---|
| Aug. 5 | 9 47 4·0 | 6 22 30·07 | 13 54 8·5 |
| „ | 10 50 33·6 | 6 22 47·52 | 13 52 5·7 |
| 7 | 10 7 18·7 | 6 41 39·76 | 12 27 27·6 |
| 9 | 9 29 3·4 | 7 9 12·24 | 10 58 10·3 |
| „ | 9 47 36·3 | 7 9 29·07 | 10 57 35·2 |
| „ | 10 17 8·5 | 7 9 46·80 | 10 56 46·9 |
| „ | 10 31 9·2 | 7 9 55·67 | 10 56 8·0 |
| „ | 10 40 23·4 | 7 10 2·31 | |
| „ | 10 48 14·9 | 7 10 9·44 | 10 55 46·4 |
| „ | 11 1 23·2 | 7 10 18·41 | 10 55 19·0 |
| 14 | 8 59 7·2 | 9 42 3·32 | 8 0 3·3 |
| 18 | 10 55 26·9 | 12 57 38·98 | 10 55 12·0 |
| 19 | 11 21 32·6 | 13 31 51·60 | 13 13 46·0 |
| 22 | 9 30 26·2 | 14 35 49·24 | 21 2 46·9 |
| „ | 9 49 40·7 | 14 36 1·31 | 21 5 3·1 |
| „ | 10 13 21·2 | 14 36 16·01 | 21 8 29·0 |
| „ | 10 27 41·9 | 14 36 25·30 | 21 10 20·3 |
| 23 | 9 47 30·1 | 14 49 59·60 | 24 41 36·5 |
| 25 | 9 53 43·8 | 15 12 9·44 | 33 14 38·6 |
| 29 | 8 51 22·9 | 15 36 43·24 | 54 37 19·8 |
| „ | 9 11 38·1 | 15 36 46·05 | 54 42 30·9 |
| „ | 9 37 15·2 | 15 36 52·64 | 54 48 51·8 |
| „ | 9 50 20·5 | 15 36 54·11 | 54 52 3·7 |
| „ | 10 8 10·4 | 15 36 57·17 | 54 56 17·8 |
| „ | 10 31 30·1 | 15 37 2·18 | 55 1 46·9 |

*Assumed Mean Places of the Stars employed for Comparison.*

| Day of Obs. | Star's Name. | Mean R.A. 1862, Jan. 1. h m s | Mean N.P.D. 1862, Jan. 1. ° ′ ″ |
|---|---|---|---|
| Aug. 7 | B.A.C. 2210 | 6 39 53·16 | 12 51 22·0 |
| 9 | B.A.C. 2210 | | |
| „ | Radcliffe 1928 | 7 11 28·81 | 11 2 20·5 |

| Day of Obs. | Star's Name. | Mean R.A. 1862, Jan. 1. | Mean N.P.D. 1862, Jan. 1. |
|---|---|---|---|
| | | h m s | ° ′ ″ |
| Aug. 14 | Groomb. 1643 | 10 21 35·42 | 8 47 50·2 |
| 18 | B.A.C. 4527 | 13 25 49·48 | 10 38 35·1 |
| 19 | Oeltz. Arg. 13813 | 13 30 39·48 | 13 13 45·5 |
| 22 | Groomb. 2129 | 14 28 33·63 | 21 18 31·1 |
| 25 | Groomb. 2211 | 15 10 2·56 | 33 21 57·2 |
| 29 | Piaz. xv. 148 | 15 33 28·78 | 54 52 20·2 |

The observations in general consisted of distinct readings of the hour-circle, and the declination circle corresponding to distinct transits and bisections of the Comet, and the comparison-stars, except on August 9, when the transits of the star and Comet were made with an unchanged position of the polar axis, the objects being in the field of the telescope together.

The results on August 5 and 23 are more doubtful than the rest through want of a comparison-star.

The observations to August 14, inclusive, were made by myself; after that time they were made by Mr. Quirling.

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*Observations of Comet II.* 1862, *taken with the Equatoreal of the Liverpool Observatory.* By J. Hartnup, Esq.

| 1862. | G.M.T. | Comet's R.A. | Log. $\frac{p}{P}$ | Comet's N.P.D. | Log. $\frac{q}{P}$ | Stars of Comp. B.A.C. |
|---|---|---|---|---|---|---|
| | h m s | h m s | | ° ′ ″ | | |
| Aug. 18 | 8 11 55·9 | 12 53 13·87 | +9·309 | 10 48 14·0 | +8·2211 | 4527 |
| 18 | 8 57 3·3 | 12 54 25·25 | +9·323 | 10 51 20·6 | −8·9740 | ,, |
| 18 | 9 42 8·7 | 12 55 36·51 | +9·321 | 10 54 28·6 | −9·3168 | ,, |
| 21 | 9 57 5·7 | 14 18 44·38 | +9·107 | 17 55 10·8 | −9·3093 | 4909 |
| 21 | 10 37 31·9 | 14 19 17·06 | +9·110 | 18 0 14·4 | −9·3688 | ,, |
| 23 | 8 11 41·9 | 14 49 11·09 | +8·864 | 24 26 13·6 | +8·1605 | 4949 |
| 23 | 8 26 47·7 | 14 49 19·24 | +8·887 | 24 28 41·1 | −7·7688 | ,, |
| 23 | 8 41 54·3 | 14 49 26·93 | +8·905 | 24 31 4·4 | −9·3188 | ,, |
| 28 | 9 12 11·0 | 15 31 41·35 | +8·656 | 48 53 23·1 | −9·6022 | 5122 |
| 28 | 9 32 12·7 | 15 31 45·58 | +8·676 | 48 58 11·9 | −9·6345 | ,, |
| 28 | 9 52 14·6 | 15 31 50·10 | +8·693 | 49 3 1·1 | −9·6655 | ,, |
| Sept. 10 | 10 27 23·6 | 16 8 0·19 | +8·514 | 108 46 30·4 | −9·9433 | 6060 |

The observations are corrected for refraction. The corrections to be applied for parallax in time, and are represented by $p$ and $q$. P is the equatoreal horizontal parallax.

The following are the assumed mean places of the stars of comparison for 1862, January 0:—

| | R.A. | N.P.D. | Authority. | | |
|---|---|---|---|---|---|
| | h m s | ° ′ ″ | | | |
| B.A.C. 4527 | 13 25 49·25 | 10 38 35·39 | British Association Catalogue. | | |
| ,, 4909 | 14 45 7·31 | 17 27 30·68 | ,, | ,, | ,, |
| ,, 4949 | 14 55 24·07 | 23 31 2·37 | ,, | ,, | ,, |
| ,, 5122 | 15 25 58·19 | 48 41 38·95 | ,, | ,, | ,, |
| ,, 6060 | 17 47 47·94 | 108 46 23·90 | ,, | ,, | ,, |

*Remarks.*

Aug. 18. Nucleus stellar, small and well defined. Tail in large telescope fan-shaped, short, and very bright. In a good opera-glass the tail appeared about 8 degrees long.

23. In the large telescope, with powers 90, 120, and 400, the nucleus was elongated, well defined, small, and bright. In the finder (power 20) the nucleus appeared round, and resembled a star of the 5th magnitude, surrounded with faint nebulous light.

28. Nucleus not so bright as on the 23d, but still well defined and a little elongated. Light of comet more diffused.

Sept. 10. Comet found with an opera-glass. In the large telescope the light was much more diffused than on previous occasions.

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*Observations of Comet II.*, 1862. By G. Knott, Esq.

The late fine (and in some respects remarkable) Comet was first seen at this Observatory on August 18th. Unfortunately I was a good deal away from home during its apparition; and this circumstance, coupled with the unsettled state of the weather, prevented my observing it so closely as I should otherwise have done.

At the suggestion of the Rev. T. W. Webb, I measured, or carefully estimated, whenever opportunity offered, the position-angle of the curious fan or jet which streamed from the nucleus; and although I am not inclined to attach much weight to my results, I think they abundantly suffice to show remarkable variations in the direction of the fan, to the extent of more than 50°. The measures were made with a wire micrometer attached to my 7¼-inch Equatoreal, the power employed being 113; and in all cases, unless otherwise stated, the angle is that of a central chord of the jet.

I proceed to give a few extracts from my journal:—

"August 18th. My first view of the comet in the Equatoreal. The nucleus is bright and sharply defined; bears magnifying well. A curious ray or jet proceeds from it, having a position-angle of 280° or 285°.

"August 25th. The nucleus evidently not in the centre of the coma. The jet is much curved. A tangent to the jet near the nucleus would have a position-angle of 235° or 240°.

"August 27th. A fine evening. With the naked eye the tail can be traced for about 20°. In the telescope the tail appears to be double. The inner edge of the longer and brighter branch is sharply defined; one measure gave its initial position-angle =75°. The southern branch short and ill-defined. At $8^h\ 45^m$ G.M.T. five measures gave the position-angle of jet =241°·5. Later in the evening, $10^h\ 40^m$, the position-angle deduced from five measures was 240°·8; approximate length of jet, 46″±.

"August 29th. Apparently an extraordinary change in the form of the jet. The nucleus very bright, sharply defined, and of an orange tint. The position-angle deduced from five measures at $8^h\ 30^m$ was 279°·0. Clouds now came up, and further observation was impossible.

"August 30th. The jet appears to have recovered its usual form. The nucleus and jet not well defined; the position-angle of the latter at $9^h\ 30^m$ estimated at 225°. Later in the evening took measures: the mean of five gave the angle at $10^h\ 7^m$ =225°·6. This was the last occasion on which I saw the Comet."

The marked changes in the position-angle of the jet are sufficiently curious, and I much regret that circumstances did not allow me to obtain a more complete series of measures. I can only hope that other observers have been more fortunate.

*Woodcroft Observatory, Cuckfield, Nov.* 11, 1862.

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## *Observations of Comet II.*, 1862. By F. Abbott, Esq.

I herewith send you the approximate positions of a fine Comet, which first made its appearance here at the early part of the month. From the 1st to the 6th the sky was so unusually cloudy as to entirely shut out the Moon's place, and also from the 6th to the 11th, from the latter date it was observed every evening with one exception, the results were chiefly obtained with the first trial of a Dallmeyer's portable Equatoreal, just imported—no correction having been made for instrumental error or refraction — the positions, however, were generally taken near the zenith.

The small sketch enclosed, taken on the 11th, will convey some idea as to the Comet's general appearance. On the 6th, it was distinctly seen in a clear sky with a Moon thirteen days old. On the 11th some measures were made on its curved tail,

about 5° in length, 40′ in diameter, with a planetary nucleus of 20″; on this evening δ *Scorpii* was seen doubly through the tail clear and well defined. On the evening of the 12th the condensed head of the Comet covered the small nebula marked 80 *Messier*, which nebula could not be seen at this time by any means I could adopt. On the 21st the Comet had apparently diminished so much as to be just visible to the naked eye when pointed out, and on the 22d it became telescopic.

| | | R.A. | Decl. |
|---|---|---|---|
| | h m | h m | ° ′ |
| 1862, Sept. 6 | 6 30 P.M. | 15 59 | 4 0 S. |
| 11 | 8 30 ,, | 16 10 | 19 40 |
| 12 | 7 20 ,, | 16 11 | 22 30 |
| 14 | 10 10 ,, | 16 13 | 26 25 |
| 15 | 7 10 ,, | 16 14 | 27 30 |
| 16 | 10 30 ,, | 16 15 | 29 20 |
| 17 | 7 35 ,, | 16 16 | 31 10 |
| 18 | 7 15 ,, | 16 17 | 32 0 |
| 19 | 7 35 ,, | 16 18 | 33 30 |
| 20 | 7 45 ,, | 16 19 | 34 30 |
| 21 | 7 30 ,, | 16 20 | 35 50 S. |

*Private Observatory, Hobart Town, Sept.* 23, 1862.

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*On the Cluster κ Crucis, R.A.* $12^h\,43^m\,36^s$, *N.P.D.* 149° 25′ 31″ (3435, *H.*) *Lac.* 1110 (*Neb.*). By F. Abbott, Esq.

This delightful cluster, "which is estimated by Sir J. Herschel to be composed of from 50 to 100 stars," most of which partake of well-marked and varied colours, forms an object that is scarcely perceptible to the naked eye, but when under proper optical influence it is one of the most brilliant and interesting objects in the Southern sky.

This cluster is not only an object of interest from the extreme beauty of colour and arrangement, but with respect also to certain changes that are apparently taking place in the number, position, and colour of its component stars.

Some hesitation might be felt in following the author of the *Cape Observations*, with the means he employed, were it not for the encouraging invitation that is given for other observers to note any remarkable change that may have taken place since those results were published. Having, therefore, no knowledge of any other observation being made, or popular

account published of *κ Crucis*, except that at Feldhausen, I have adopted it for comparison with the observations now made, and given in the drawing for the present epoch.*

The colour of all the stars, where distinct colour could be detected, is given on the drawing; the smaller stars, however, from the 10th to the 14th magnitude, are generalised, and all partake of nearly the same colour (Prussian blue), some with a little more or less tint of red or green mixed with the blue. The same Greek letters have, with one exception, been used in the drawing as those used for the Cape Monograph, but not exactly following those used in the Catalogue. The letters and numbers, when in combination, are grouped together in brackets, and intended to show colour and position only.

The 75 stars which are given in the drawing were observed, and their position laid down by means of a 5-foot achromatic telescope, with a $4\frac{1}{4}$-inch object-glass of excellent quality. The power used for the purpose of laying down the position of the stars was 135; but for the colours a comet eyepiece of 27 was found preferable.

The colours, as well as the positions, were afterwards checked with a 7-foot achromatic by Dollond. The evening of the 24th of May was chosen for confirmation: it was a capital night — no moon, quite calm, and the object near the zenith; but with such a night I was not, with the means employed, able to bring out stars of the 15th and 16th magnitude given in the Cape Catalogue.

In the *Cape Observations* $\varphi$ is laid down to the west of $\varepsilon$ and $\delta$; they are now, however, situated in a straight line, which, when continued, reaches the star $\zeta$; a straight line also, drawn through $\alpha$ and $\beta$, cuts $\delta$; but the two conspicuous stars in the drawing, $\gamma$ and $\theta$, as well as the three small stars marked 12 above the belt, are not shown at all in the Cape Monograph; there are also two considerable stars, $\varkappa$ and $\lambda$, to the far west, which are not seen in the Cape description.

The two stars, $\alpha$ and $\beta$, apparently retain their colour; but $\gamma$ has changed from greenish white to blueish purple; $\delta$ from green to pale cobalt; $\varepsilon$ from red to Indian red; $\zeta$ from green to ultramarine; $\varphi$ (marked $\eta$ in the drawing) from blue green to emerald green; $\alpha^2$, called ruddy, partakes now of much the same colour as all the small stars of that magnitude.

*Private Observatory, Hobart Town,*
*May* 1862.

* The drawing was exhibited at the November Meeting of the Society. — Ed.

## *On the Identity of the Triple Star* H I. 13.

By the Rev. W. R. Dawes.

This object is thus described by Sir W. Herschel in his first Catalogue of Double Stars:—

"July 25, 1781. In Constellatione *Aquilæ*, near Fl. 37. A curious treble star. It is the last star of a telescopic trifolium n. following *k*, similar to that in the hand of *Aquarius*. The two nearest very unequal; the third star excessively small, and not visible with 227. The two nearest with 460, no more than half diameter of L; the farthest about 7″ or 8″."

The two nearest were measured by Sir James South at Passy in July and August 1825, with his 7-foot refractor of 5 inches aperture; but on the night of the 28th of July, which he describes as "very favourable for difficult observations," he records, "Sir W. Herschel having described it as a triple star, I applied a power of 413; but no third star could be even suspected." It is distinguished as S 720.

In the Dorpat Catalogue of 1827, Struve has thus described his No. 2541:—"2541, P. xix. 185; $\alpha = 19^h\ 27^m{\cdot}3$; $\delta = -10^\circ\ 48'$; I. (9) (10.11) = H I. 13." And his No. 2545 is described thus:—"2545, $\alpha = 19^h\ 29^m{\cdot}0$; $\delta = -10^\circ\ 32'$; I. (6) (8)."

In his "Adnotationes" at the end of the Catalogue, he remarks, with reference to "No. 2541, P. xix. 185. Hanc stellam H I. 13 posui. Est quidem egregia altera duplex classis I. in vicino, No. 2545. Sed hæc est stella magnitudinis sextæ, qualem *Herschelius* non videtur observasse. Neutram tamen triplicem vidi, qualis H I. 13 esse debet."—In his *Mensuræ Micrometricæ*, p. 80, he gives three nights' measures of No. 2541; and at p. 53, five nights' measures of No. 2545. Attached to the former is the remark,—"Dubitari potest utrum hæc stella an 2545 sit Herscheli I. 13."—Though No. 2545 was observed on five nights, on three of which power 480 was used, and on one 600, yet no third star was ever perceived.

There is a second triple star in this vicinity, No. 2547 of Struve's Catalogue. Its Right Ascension is about $12\frac{1}{2}^s$ greater than that of 2545, and it is about 11′ further south. This was observed by Struve on three nights, but *only as double.*

Sir John Herschel reobserved S 720 on three nights in 1828 and 1830. (Nos. 553–555 of the 364 Double Stars. *Mem. R. Ast. Soc.* vol. v. part i. p. 69). In one of his notes at the foot of the page he remarks, "Taken for Σ 2545;" and in another, "This is S 720. It cannot be H I. 13." *Why*, is not stated. No third star was seen on any occasion. Sir John also observed a double star which he designates Σ 2545 (No. 556 of the 364); but the angle of position differs so widely from Struve's, that either there is a large error in it, or another object has been observed, which, however, I have failed to find. No. 557 is rightly called Σ 2547, and the

position and distance agree well with Struve's; but the third star has escaped Sir John as well as Struve.

In 1835, Admiral Smyth observed two objects in this locality, which constitute Nos. 702 and 703 of the "Bedford Cycle." The former is marked as *triple;* the latter as *double only.* No. 702 is thus described:—"A delicate triple star, on the right knee of *Antinous.* . . . A 9, light yellow; B 10, cerulean blue; C 12, violet tint; and the three lie nearly in a line pointing to a distant small star in the *s. f.* quadrant."—It is stated to be P. xix. 185, and to be identical with H I. 13, with S 720, and with Σ 2541,—the positions and distances of those stars, as determined by the respective observers, being quoted for comparison. With reference to the third star overlooked by Struve and South, he adds, "It is plain enough in my refractor. I therefore conclude Sir James must have measured the following instead of 13 H I." Smyth gives as the results of his own observations of 702:—

| | | | |
|---|---|---|---|
| A B | P = 338°·4 (*w* . 4) | D = 3″·2 (*w* . 2) | Epoch 1835·58 |
| A C | 153°·5 (*w* . 2) | 8″·0 (*w* . ) | |

And the mean place of the star for 1840 is given thus:—

| | |
|---|---|
| R.A. 19h 28m 1s | Prec. + 3s·30 |
| Decl. S. 10° 46′·8 | — N. 7″·51 |

Of the Cycle No. 703, Smyth gives as the mean place for 1840:—

| | |
|---|---|
| R.A. 19h 28m 5s | Prec. + 3s·30 |
| Decl. S. 10° 30′·4 | — N. 7″·52 |

and he considers it to be identical with P. xix. 186.

As the results of his measurements of this star he gives:—

P = 315°·7 (*w* . 6) D = 3″·8 (*w* . 3) Epoch 1835·58;

and he describes the object thus:—"A very neat double star on the right knee of *Antinous*, and closely following the above-described object. A 7½, pale white; B 9, sky-blue; and they are followed by another double star nearly on the parallel. There can be little doubt of this object's having been measured for 185 P.; for, though it is considerably brighter and more open, yet there is certainly a great resemblance in the position and distance of A and B. This is the No. 2545 of the great Dorpat Catalogue."

Wishing to determine, if possible, which of the two objects in this vicinity at all resembling H I. 13, was really that star, in October 1859 I directed toward the place my 8¼-inch re-

observer. Having identified 37 (*k*) *Aquilæ*, which is, in fact, a good fifth magnitude star, and plainly visible to the naked eye, I carefully examined all the stars north-following 37 which were visible along with it in the finder of 2 inches aperture and power 23. The nearest double star to 37, and, with reference to that star, about 8′ 35″ n. f. $2^m\ 12^s$, was obviously Σ 2541; the second was about 24′ 44″ n. f. $4^m\ 7^s{\cdot}5$, and agreed in place with Σ 2545; and a third was about 13′ 41″ n. f. $4^m\ 20^s$, and agreed in place with Σ 2547. The mean place of 37 *Aquilæ* deduced from the B. A. C. was for 1860·0, R.A. $=19^h\ 52^m\ 52^s{\cdot}66$, and N.P.D. $= 100°\ 52'\ 52''{\cdot}5$. In referring to each of these objects I shall designate them by Struve's numbers.

Σ 2541. Instantly seen *double;* looked carefully for a third star; none could be found. Magnitudes, A = 8½; B = 9½. Pos. = 340° ±; Dist. = 2″·5 ±.

Σ 2545. Instantly seen *triple*. Mag. A = 6½; B = 8; C = 11¼, *blue*. A B, Pos. = 315° ±; Dist. = 3″·0 ±. A C, Pos. = 170° ±; Dist. = 25″ ±.

Σ 2547. Obviously *triple*. Mag. A = 7½; B = 9; C = 10½. A B, Pos. = 330° ±; Dist. = 20″ ±. A C, Pos. = 140° ±; Dist. 45″ ±. *The three are nearly in a line.*

Of these three objects, I have not the slightest doubt that the *second*, Σ 2545, is H I. 13.

The only circumstance which presents any difficulty in the way of this conclusion is, that the distance of C from A is much greater than was estimated by Sir W. Herschel. But the marvel rather is that he *discovered* it at all with his 7-foot Newtonian; and a mere guess at the distance of a scarcely perceptible point of light may easily be much in error. A similar and very remarkable instance occurs in the distance of A C of Cycle 702, which was estimated by Smyth at 8″, though its real distance is between 40″ and 50″. It was, in fact, a mere guess, with *no weight* attached to it.

That the third star of H I. 13, should have escaped the scrutiny of such observers as South, Herschel II., Smyth, and especially Struve with his powerful Dorpat refractor; and yet should have been seen at all by Herschel I. with a reflector of only 6⅓ inches aperture (about equal in light to a refractor of 4½ inches aperture), and then, after lying hid for nearly eighty years, should have been caught up at the first glance with a telescope 1⅓ inch smaller in diameter than Struve's (and whose illuminating power is therefore only as 68 to 92) might seem almost with certainty to point to *variability of light*, as the only probable solution of the difficulty. Yet, during three years, since 1859, I have on various occasions examined it with a special view to this point, and have never found any proof of it, or even ground of suspicion. It is true that on a very clear night (19th August, 1862) I saw it with a refractor of only 4 inches aperture by Cooke of York, and with so low a power as 135; but, on viewing it with my 8¼-inch, I found

that all the faint stars in the neighbourhood were proportionably brighter than usual from the transparency of the atmosphere. The fact that Struve on three different nights overlooked the third star of Σ 2547, of which Smyth says, "It is plain enough in my refractor," and which has three or four times the light of the third star of Σ 2545 (H I. 13) is sufficient to show how easily such objects may be rendered invisible at a small altitude by a little unsuspected haze. Yet it would be highly desirable that this object should be put upon the list of "Suspected Variables." Of course, at such an altitude, great caution is required; and it will be necessary to compare it with two or three very faint objects in its immediate vicinity.

*Hopefield Observatory, Haddenham,*
*October 1862.*

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## *Remarks on some Astronomical Eye-pieces.*

By the Rev. W. R. Dawes.

As the improvement of astronomical eye-pieces must always be interesting to telescopic observers, it is hoped that a few remarks on that subject may not be unacceptable. They will have special reference to a paper by Mr. T. W. Burr, printed in the *Monthly Notices* for June 1862, in which he particularly recommends an eye-piece lately constructed by Mr. Thornthwaite, and, in consequence of its freedom from the defects of those in ordinary use, named the "Aplanatic" eye-piece.

It does not appear to be generally known that the late Carl Kellner, of Wetzlar, in Prussian Rhine, employed the same, or very nearly the same, form for his telescopes as for his microscopes — I have seen several of them. The field-lens in all was double convex; and so nearly equi-convex (in some, at least) that I could not discover that they were not exactly so. The eye-lens was a meniscus; and they all had a stop, or diaphragm, in the focus of the meniscus, and very near the field-lens. One of these, which produced a power of 80 on my telescope, had a field of 37′ 10″ in diameter; and, consequently, the angular subtense of the diaphragm = 49° 33′. Being directed to the full moon on the 8th of November, 1851, it embraced the whole of it with a considerable margin. On that night the moon's diameter was 30′ 6″; and, consequently, the breadth of the margin all round it was 3′ 32″. The focus being carefully adjusted on a well-defined object near the centre of the moon, the edge was very distinct all round without any perceptible colour.

In the year 1855, Professor Steinheil of Munich sent me three eye-pieces, the construction of which he considered an

improvement on Kellner's; the eye-lens being rendered achromatic by being composed of a double convex of crown-glass, and a plano-concave of flint-glass, cemented together. This seems to be precisely the same combination as that of Mr. Thornthwaite's eye-lens, as described by Mr. Burr; and if so, it has already been in use for more than seven years. After many comparisons I have arrived at the conclusion, that there is little, if any, advantage in this construction over Kellner's *as made by himself*.

Mr. Burr states that "the division of double stars is rendered easier by this [aplanatic] eye-piece. . . . Persons who could not see ε *Lyræ* quadrupled with the Huyghenian of 123 had no difficulty in doing so with the aplanatic, &c." This is certainly very extraordinary. I have for many years been in the habit of showing this quadruple star, with a refractor of only $2\frac{1}{2}$ inches aperture, to persons who had never seen the object before; yet no one has ever experienced any difficulty in perceiving both pairs to be double at the same time (without bringing each into the centre of the field) with the ordinary Huyghenian eye-pieces magnifying 93 and 134 times; and, as the two pairs are only about $3\frac{1}{2}$ minutes of arc apart, this circumstance has never been supposed to indicate peculiar excellence in the eye-pieces. I have lately tried on this object with the same telescope a Huyghenian eye-piece by Tulley producing a power of 120, with which it was impossible for any one to overlook the duplicity of both sets seen at once. I presume that this condition (both pairs being seen double at the same time, and of course in different situations in the field of view) is one particularly dwelt upon in the comparison; because, if each is brought nearly into the centre, very little difference is produced in the image by the use of any of the various kinds of eye-piece, whether merely a single lens or composed of two. Under favourable atmospheric circumstances I have examined α *Lyræ* near the meridian with almost every variety of eye-piece,—the Huyghenian, Kellner's, and Steinheil's negatives, Ramsden's positive, or micrometer, both with ordinary and achromatic lenses; with double convex, crossed, plano-convex, and achromatic lenses;—but when the powers were nearly equal, I could perceive no difference in the definition of the disk, or in the formation of the optical rings round it; the object being, of course, placed in the centre of the field, and kept there by the driving-clock. It is, however, obviously of the utmost importance in arriving at a correct result in such a comparison, that the lenses should all be good. Any imperfection in their material or figure or workmanship may be immediately detected by a distortion of the disk of a bright star, or of the rings surrounding it; and the nature of the imperfection may probably be discovered by lengthening the focal adjustment considerably, when the defect will appear on the diffused image.

In reference to the size and distinctness of the field in compound eye-pieces, it is of course necessary, not only that the lenses should be good, but also that their focal lengths and distances from each other should be duly proportioned and adjusted. It is quite possible that any comparative inferiority in a compound eye-piece may arise, not so much from the character of its combination, as from some fault in its construction. For instance, — any Huyghenian eye-piece producing a power of about 125 on a good telescope of two and a half inches or more in aperture, which failed to show ε *Lyræ* quadruple, may on that very account be reasonably suspected of being imperfectly constructed, and therefore unfit to be employed as a standard of comparison for others.

I have lately had an opportunity of examining a Comet eye-piece made by Mr. T. Cooke of York on Kellner's plan, which fully comes up to the standard of those made by Kellner himself; the angular subtense of the diaphragm being nearly 50°, with remarkable distinctness and freedom from colour to the edge of the field.

In the "achromatic positives," as constructed by Steinheil, the eye-lens is a double achromatic; and there is an almost complete correction of colour to the edge of the field, which would be particularly advantageous in taking wide measures with the filar micrometer. In three which I have, however, the spherical aberration is over corrected, requiring the eye-piece to be a little withdrawn to bring the web into focus when far from the middle of the field. An eye-piece of this form, with large lenses and of low power, if correctly constructed so as to unite flatness of field with achromaticity, would make an excellent comet eye-piece; and it would be even more valuable for the annular micrometer, in which the colour infesting the objects and the edges of the rings in the micrometer, is a serious impediment to the accuracy of observation.

In the preceding remarks I have spoken of the *angular subtense* of the diaphragm of an eye-piece. This is a very useful *constant*, and may be easily determined by various processes.

1. Fix the eye-piece so that its diaphragm as seen with one eye can be projected on a wall, or a perpendicular staff, as seen with the other. Let an assistant mark the points on the wall cut by the upper and lower edges of the projected diaphragm, which will denote its apparent vertical diameter. Measure the distance between them, and also the distance of the wall from the eye, which should be opposite to the middle of the projected diaphragm. Then the angular subtense of the diaphragm will be found by the following formula:—

$$\text{Tangent } \tfrac{1}{2} \text{ angular subtense} = \frac{\tfrac{1}{2} \text{ projected diameter of diaphragm}}{\text{distance of the eye}}.$$

2. Another method of determining the same constant, and probably with greater accuracy, is by noting the time occupied by an equatoreal star near the meridian in traversing the diameter of the diaphragm of the eye-piece applied to a telescope. The magnifying power on that telescope being ascertained by a dynamometer or otherwise, the angular subtense is obtained by the formula,—

$$\text{Angular subtense} = \text{time noted} \times 15 \times \text{magnifying power.}$$

3. Where the eye-piece can be applied to an instrument having circles divided with sufficient minuteness, the diameter of the diaphragm in arc on that telescope can be obtained from the readings of the vertical circle, by bringing a star or any other well-defined object to the southern and northern extremities of the diameter, and taking the difference of the readings; then

$$\text{Angular subtense} = \text{angular diameter} \times \text{magnifying power.}$$

It is obvious that the angular subtense, or constant, of any eye-piece having been determined, the magnifying power produced by that eye-piece on any telescope may be readily found by merely observing the diameter of the field by any of the above-mentioned methods; when

$$\text{Magnifying power} = \frac{\text{angular subtense}}{\text{angular diameter}}.$$

Thus the diaphragm of an eye-piece whose *angular subtense* is 50°, if applied to one eye, and projected on the sky viewed with the other eye, would just include at the upper edge a star whose altitude is 50°, when the lower edge coincided with the true horizon. If such an eye-piece were applied to a telescope, and an equatoreal star were found to occupy two minutes in traversing the diameter of the field, the *angular diameter* on that telescope would be 30′, and the magnifying power 100.

As the focal images formed by an object-glass lie in a spherical surface of which the radius is the focal length, it is obvious that even if the spherical aberration of an eye-piece were perfectly corrected, it could not be free from the defect of indistinctness at the edge of a field of considerable extent. I am not aware that any successful attempt has been made to *over*-correct the spherical aberration of the Huyghenian eye-piece by making the *field*-lens a compound one; though there would seem to be no impossibility in the way of its accomplishment.

*Hopefield Observatory, Haddenham,*
*Thame, September* 1862.

*On Aluminium Bronze as a Material for the Construction of Astronomical and other Philosophical Instruments.* By Lieut.-Colonel A. Strange, F.R.A.S.

The author, after referring to the Astronomical and Geodesical instruments about to be constructed, under his superintendence, by order of the Government, for the use of the Great Trigonometrical Survey of India, and after noticing that one of the points which has given him most anxiety had been the selection of the proper material or materials of which to construct these instruments, and that his present remarks were confined to the great Theodolite with a horizontal circle 3 feet in diameter, and after detailing the requirements of such an instrument, proceeds as follows:—

"Such then was the problem presented for solution: to construct an instrument with extended powers, and cast as much as possible in masses, the transportation of which, over the most difficult ground, should not be beyond the power of human labour.

"When on the point of compromising the difficulty by separating, so as to form distinct packages, parts hitherto regarded as inseparable, my attention was attracted by the various articles made of 'Aluminium Bronze' sent to the International Exhibition by Messrs. Bell Brothers, of Newcastle, and M. Morin, of Paris. The inquiries I made in various quarters satisfied me that this metal possessed most valuable qualities, but I failed in my endeavours to obtain reliable numerical data for comparing it with other metals. I therefore instituted experiments on it, the results of which I beg now to communicate to the Society.

"The alloy called Aluminium Bronze was first, I believe, made by Dr. Percy five or six years ago, and is composed of Aluminium and Copper in various proportions, 10 per cent of Aluminium, however, giving the best material for mechanical purposes.

"The qualities of most importance in instrument making are, (1) Tensile strength; (2) Resistance to compression; (3) Malleability; (4) Transverse strength or rigidity; (5) Expansive ratio; (6) Founding qualities; (7) Behaviour under files, cutting tools, &c.; (8) Resistance to atmospheric influences; (9) Fitness to receive graduation; (10) Elasticity; (11) Fitness for being made into tubes; (12) Specific gravity.

"Of these, tensile strength, resistance to compression, and malleability, were most obligingly tested for me by Mr. Anderson at the Royal Gun Factory, Woolwich; and the other qualities by Messrs. Simms, by whom the great Theodolite is now being constructed. I will take the above enumerated properties in their order, premising that to have obtained results of an absolute and final character would have involved more time than I could spare, and that therefore those which follow, though sufficiently reliable for almost any practical

purpose, are open to the correction of more extensive experiments.

"(1) *Tensile strength.* This was tried some years ago by Mr. Anderson with the following results. Breaking strain

| | | |
|---|---|---|
| Aluminium bronze . . . | 95,747 | lbs. per square inch. |
| Gun metal . . . . . | 32,000 | |

"Mr. Anderson was good enough to try it again for me in September last, and states in his report, 'The average tenacity of this metal proved to be 22 tons 12 cwt. (50,624 lbs.) breaking weight per square inch in the two specimens tested; elongations did not take place until 4300 lbs. in the one case, and 3600 lbs. in the other, had been applied, when a permanent elongation was noticed of ·009 of an inch in the first specimen, and ·034 of an inch in the last.' Mr. Anderson adds that the specimens were not quite sound.

"In the above cited report Mr. Anderson gives a higher tensile strength to gun metal than before, namely, 17 tons (38,080 lbs.) for the average of the '*best specimens*' tested at the gun-factories.

"Combining the results we have the average breaking tensile strength of the two metals as follows:—

| | | |
|---|---|---|
| Aluminium bronze | $\frac{95747 + 50624}{2} = 73{,}185$ | lbs. per square inch. |
| Gun-metal | $\frac{32000 + 38080}{2} = 35{,}040$ | |

the ratio being 1 to 0·48, or rather more than 2 to 1 in favour of aluminium bronze.

"For the purpose of comparing the tenacity of the new alloy with steel, we have data given by Mr. Anderson in a lecture* on Materials for Rifled Cannon, in which he states that cast steel varies in tensile strength from 114,000 to 67,000 lbs. per square inch; but he objects to the higher qualities as liable to brittleness, and prefers, where great strains are in question, an average quality of cast steel breaking at 80,000 lbs.; and he adds, that specimens from a gun made of Krupp's famous cast steel, characterised by 'softness' (which Mr. Anderson considers favourable to tenacity) and 'perfect soundness,' gave 72,000 lbs. per square inch, which we see is 1185 lbs. less than the average strength of aluminium bronze above given.

"(2) *Resistance to Compression.* Mr. Anderson reports on this as follows:—

"'The ultimate amount of compression applied was 59 tons, 2 cwt. 1 qr. 4 lbs. (132,416 lbs.), under which the specimen† [illegible]

* Published in No. XXIII. *Journal*, Royal United Service Institution.

† "The specimen subjected to this enormous pressure, distorted though it is, does not exhibit the trace of a fissure. The cohesion of its particles is inviolate."

became too much distorted to permit of more weight being applied with any true result. Compression was not perceptible until 9 tons, 2 cwt. per square inch (20,384 lbs.) was applied, when the specimen suddenly gave to the extent of ·006 of an inch, and on the weight being removed an elasticity of ·001 was observed, which gives the first permanent compression as ·005 of an inch.'

"The 'compressive strength of cast iron varies a good deal. That of 'Carron Iron, No. 3,' the highest given in Ure's *Dictionary of the Arts*, is 115,542 lbs. per square inch; but it is difficult to compare in this respect two metals whose behaviour under compression is so different, cast iron yielding suddenly and almost totally, and the new alloy more gradually and partially. Astronomical instruments, however, are more dependent on the rigidity or resistance to a transverse force than to any other quality.

"(3) *Malleability.* Mr. Anderson states on this head:—

"'The qualities of this metal for forging purposes would appear to be excellent; with the exception of the part heated to a red heat in the shade, all show that it is a good workable material under the hammer almost up to melting point.'

"I may add that there were specimens in the Exhibition, showing that the alloy could be drawn out under the hammer almost to a needle point.

"I come now to the experiments tried by Messrs. Simms.

"(4) *Transverse strength.* As the absolute determination of the force necessary to break or permanently bend a bar of metal was beyond our appliances, I begged Messrs. Simms to be satisfied with a comparative value of the rigidity of the new alloy; that is, to ascertain the relative resistances of gun metal, brass, and aluminium bronze, to a force insufficient to produce permanent flexure. This they succeeded in doing, and report as follows:—

"'The same weight applied to three bars altered the index of our instrument as under,

| | |
|---|---|
| Brass . . . . . | 2·22 divisions |
| Gun metal . . . . . | 0·15 ,, |
| Aluminium bronze . . . . | 0·05 ,, |

"Hence, aluminium bronze would appear to be 3 times more rigid than gun metal, and upwards of 44 times more rigid than brass.

"(5) *Expansive ratio.* This determination was also a comparative one. Messrs. Simms found that 'aluminium bronze is less affected by change of temperature than either gun metal or brass, (a little less than gun metal, and much less than brass).'

"(6) *Founding qualities.* Regarding this there is ample experience. The alloy produces admirable castings of any size.

"(7) *Behaviour under files, cutting tools, &c.* In this respect, also, it leaves nothing to be desired. It does not clog the file; and in the lathe and planing machine the tool removes long elastic shavings, leaving a fine bright, smooth surface. Messrs. Simms state,—

"'It can be worked with much less difficulty than steel, and we should think that screws made of it would (notwithstanding the original great cost of the metal) prove in the end less expensive than screws made of steel.'

"(8) *Resistance to atmospheric influences.* Messrs. Simms state, 'it does not readily tarnish.' This, likewise, is entirely a relative question. Absolute inoxidizability, however desirable, is hardly to be expected. Suffice it, that the new alloy tarnishes much less readily than any metal usually employed for astronomical instruments, viz., gun metal, brass, silver, cast-iron, or steel.

"(9) *Fitness to receive graduation.* Messrs. Simms state, 'Aluminium bronze takes a fine division, and it will not be necessary to inlay another metal, as is usually done, to receive the graduation.' This opinion is fully justified by the specimen of graduation executed by Messrs. Simms, the lines of which are remarkably pure and equable, characteristics never presented, in the same degree, they inform me, by lines cut on any other *cast* metal. May not this superiority indicate that the alloy in question is peculiarly homogeneous? The lines are very distinct under the microscope, notwithstanding the yellow colour of the metal.

"(10) *Elasticity.* I possess no direct experiments bearing on this point. But that the alloy has considerable elasticity is unquestionable. I may here state that an eminent Parisian Instrument-maker informed me that of all the wires tried for the suspension of Foucault's Pendulum for illustrating the rotation of the earth, none, not even those of steel, were so durable under that severe ordeal as wires made of aluminium bronze. It would appear, therefore, to be the most proper material for the suspension springs of clock pendulums.

"(11) *Fitness for being made into tubes.* It admits of every process necessary for this purpose. It can be soldered with either silver or brass solder; it can be rolled into sheet metal; and it can be hammered and drawn. Hitherto telescope tubes, the cones of transit axes, the pillars of altazimuths, &c., have been made almost exclusively of yellow brass, a metal very deficient in rigidity. Gun metal does not admit of being rolled, and has therefore never been used for the tubular parts of instruments, for which the new alloy seems pre-eminently suitable.

"(12) *Specific gravity.* The specific gravities of alloys of aluminium and copper, as determined by Messrs. Bell, are

| | | | |
|---|---|---|---|
| 3 per cent. of aluminium | . | . | 8·691 |
| 4 ,, ,, | . | . | 8·621 |
| 5 ,, ,, | . | . | 8·369 |
| 10 ,, ,, | . | . | 7·689 |

The last named, which is the best for the purposes now under notice, is very nearly the same as that of wrought iron, and less than that of either brass or gun metal.

"It appears from these experiments, and from the concurrent testimony of those who have given it a fair trial, that the 10 per cent Aluminium Bronze is far superior, not in one or some, but in every respect, to any metal hitherto used for the construction of Philosophical Apparatus, and that for such purposes it may be employed in the dimensions that would be proper in the case of cast steel. All parts which otherwise would be made of steel may, with perfect safety, and even with advantage, be made of the new alloy, particularly such parts as bolts, and fixing, tangent, and micrometer screws. Its hardness and comparative inoxidizability point it out as peculiarly adapted for pivots, axes, and bearings. If employed for receiving the graduation of circles, the necessity for inlaying another metal will be obviated, by which two advantages will be gained; the hammering which forms part of the operation of inlaying, and which, more or less, must cause unequal density and tension in the circle subjected to such treatment, will be dispensed with; and the effect of inequality of expansion in the circle and the inlaid strip will no longer be a cause of apprehension. With respect to the due visibility of divisions cut on this metal, opinions will perhaps differ. I can only say that I should be well content to observe with them.

"The use of this alloy for the construction of the new Great Theodolite is, in the opinion of Messrs. Simms, and in my own, fully justified by what we now know of it; and the effect of using it will be to keep the weight of the instrument within reasonable limits, notwithstanding its possession of means and appliances not hitherto bestowed on such instruments.

"Two points remain; the making of the alloy, and its cost.

"The metal Aluminium is at present extracted in England by one firm only, Messrs. Bell Brothers, Newcastle, under a license from M. Deville, the French discoverer of the process. I have met with instances of failure in making the alloy with Copper. Two main points only, however, seem to require particular attention. First, extremely pure copper must be used. The best is copper deposited by electricity, but that kind is very expensive; the next best is copper from Lake Superior, which makes an alloy of excellent quality. The ordinary coppers of commerce generally fail, owing, it is said,

chiefly to the presence of iron, which appears to be specially prejudicial. The second precaution is to re-melt the alloy two or three times. The first melting of 10 aluminium and 90 copper produces an alloy of excessive brittleness. Each successive melting, up to a certain point determined by the working, and particularly the forging, properties of the metal, improves its tenacity and strength. It is probable that after several meltings there will remain in combination with the copper a somewhat smaller proportion of aluminium than 10 per cent.

"The present price of the English made 10 per cent. Aluminium Bronze is *6s. 6d.* per lb., but there is reason to believe that, as the process of extracting the aluminium becomes more largely practised, and the demand for the metal increases, the price will fall. The above price is four or five times that of gun metal. A much smaller quantity, however, of the new alloy than of gun metal will give the same strength; and when it is considered how small a ratio the cost of the material bears to the cost of workmanship in refined apparatus, it will be found that even at the present price of the new alloy its cost is not prohibitory, whilst the advantages attending its use promise to outweigh the increased expenditure.

"In the foregoing paper, which I am aware is very imperfect and incomplete, I have sought no more than to contribute such an instalment of practical information regarding this remarkable material as may be of service to those, who, like myself, contemplate making use of it, of whom I trust there will be many, for by its use we shall, I venture to think, confer on such structures at once greater strength and less weight, and so diminish tension, flexure, and distortion, to an extent calculated sensibly to improve the higher order of instruments of physical research.

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*On the Solar Energy as manifested in the Autumn of* 1861 *and a Portion of the Spring of* 1862. By W. R. Birt, Esq.

During the summer of 1860, both previous to and in connexion with the great outburst of solar energy, that occurred towards the end of June in that year, I noticed a very marked monthly maximum and minimum of solar spots; and while there existed indications of an intermittent action of the solar force, I was satisfied that the maxima and minima I had frequently noticed were dependent on the rotation of the Sun.

Regarding each group of spots, single spots, if unattended by smaller ones, or separate nuclei if they were sufficiently distinct to warrant the appellation, as centres of energy, I laid

down from time to time curves of which the centres of energy were the ordinates.

Taking the solar meridian turned directly towards the Earth at noon of the 9th of July, 1861, equal to 270°, and employing the period of $27^d\ 7^h\ 10^m$ as that of the synodical rotation of the Sun, I set off 27 abscissa, each being distinguished by a Roman numeral I. to XXVII. preceded by the zero; and as the rotation of the Sun apparently carries a meridian about 13°·19 westwardly per diem, each ordinate may represent any solar meridian within the limits of 13°·19; thus the zero may represent any meridian between 353°·41 and 6°·59, and XIV. any one between 178°·02 and 191°·20, and so on.

I have the pleasure of submitting to the Society the curves of five synodical rotations from observations in August, September, and October, 1861, and April and May 1862.* Each presents a well-marked maximum, and the indications of minima are also apparent. The maxima are, without exception, acuminated, showing in each case not so much a diminution of energy as a removal from observation of the active solar surface by rotation.

The most instructive feature of the curves consists of the portions of the surface of the solar globe indicated as manifesting the greatest energy. 1861, August, the meridians 23° to 208° manifested the greatest energy during the period; indeed, a much greater activity than the opposite hemisphere. During the next rotation the energy was greatly subdued; the curve, nevertheless, exhibited *an increase* of force between 125° and 297°; and by projecting the September under the August curve, the similarity of features, as regards the increase and diminution of activity, is unmistakeable.

The October curve, after presenting us with a solar hemisphere perfectly quiescent, meridian 42° gives us increased action from 108° to 293°; indeed, there had been an increase of activity since 42° was central. Collecting these areas of increased energy, we have a portion of the solar surface extending over 274°, manifesting considerably more energy than the remaining portion of 86°. The following are the meridians of maxima:—August, 156°; September, 138°; October, 200°; and this extent of 62°, or thereabouts, may be regarded as the locality of greatest energy for those months, as referred to heliographic longitudes. The heliographic latitudes of solar energy are well known.

1862 the April curve exhibits subdued energy from meridians 14° to 173°, then increased energy to 332°, with a maximum at 292°. The May curve manifests during its earlier portion more activity than the April, with a minimum

* The drawings of these curves were exhibited at the Meeting in June last.—Ed.

at 156°. This was the meridian of maximum in August, so that the activity on the hemisphere, of which 156° is the central meridian, is now greatly reduced: in fact, the direction of the curve is reversed. From this meridian the curve manifests increased energy. The two curves for April and May presents as perfect an agreement in their features as those of August, September, and October, 1861. At the present time the hemisphere of greatest energy is marked by the central meridian 300°, or thereabout.

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*On a remarkable Chain of Lunar Craters forming a portion of the Southern Boundary of the Mare Serenitatis.* By W. R. Birt, Esq.

The chain of Craters I am about to describe is but very seldom seen. I have only obtained three good views of it during the last eighteen months, viz., in 1861, April 16; 1862, May 5 and October 29. It is situated on the southern border of the Mare Serenitatis, between the conspicuous Crater Menelaus and a promontory running into the apparently open space forming the common boundary of the Maria Tranquillitatis and Serenitatis. This promontory is known as the Promontorium Acherusia.

The interest attaching to this chain of Craters will depend most probably on its having been overlooked both by Schröter, and Beer and Mädler. Although the Craters are small (they are larger than those in the neighbourhood of Eratosthenes) and situated on a narrow wall of rock running between the Maria Tranquillitatis and Serenitatis (if it be not situated on the surface of the Mare Tranquillitatis), the wall of rock rising nearly perpendicularly from level surfaces on the north and south of it, yet the locality is sufficiently remarkable, combined with the rarity of catching a sight of the Craters, to render it important to place a notice of their existence on record in the archives of this Society.

I first saw them in the year 1861, on April 16, my observations extending from 8 hours to 9·30, Greenwich Mean Time. The following is a quotation from my Journal of that date:—

"The Mare Serenitatis is separated from the Mare Tranquillitatis by a well-defined steppe, the Serenitatis being at the lower level.* From the Apennines, past Menelaus, to a point opposite Plinius, the border of the Mare Serenitatis is rugged, the highest portion of the wall from Menelaus to the terminating point consisting of a chain of small Craters—they are on the surface of the Mare Tranquillitatis, and appear at this epoch exceedingly interesting from their proximity to each other, the

* This steppe is admirably shown on one of Mr. De La Rue's photographs.

black shadows contrasting with the highly illuminated opposite rims. From the most western of these Craters, to Webb's Mount Argæus, the surface is very smooth, but the line of demarcation between the Maria Tranquillitatis and Serenitatis is well seen, and is exceedingly well defined towards its eastern extremity, near the small Craters. It is almost lost in the neighbourhood of Mount Argæus . . . . These Craters are exceedingly interesting, projecting, as they do, *alone* without any accompanying *ruggedness* into the smooth surface of the Mare Tranquillitatis."

On the 5th of May, 1862, I had an opportunity of minutely inspecting these Craters, and described in my Journal the wall in which they occur, from the Promontorium Acherusia to about one-third of the distance from the promontory to the bright Crater Menelaus, when the terminator skirted the eastern edge of the Mare Serenitatis. A quotation from my Journal will be the best description I can give:

"About two-thirds of the wall S.S.W. of the Mare Serenitatis, from the Promontorium Acherusia to the bright Crater Menelaus, is formed of small Craters interspersed with brighter portions hardly of the nature of peaks. The termination of the promontory is a bold, jutting, but low rock; it is succeeded by three deep Craters, hardly distinguishable from each other; they are quite in shadow. Two rocks and another Crater, which is isolated, form the further continuation of the wall. None of these Craters are given by Beer and Mädler. They are succeeded by a somewhat low portion of the wall to near the locality of the Crater B, of Beer and Mädler, where a jutting rock is seen. Adjoining and abutting on the Crater B, is another small, deep Crater, making the fifth from the termination of the promontory. The Crater B is nearly double the size of the small one on the border north of it, and it has a mountain on the south-west. Schröter has delineated it as being very much larger than Taquet, he marked it *g*. At a very little distance from the small Crater on the border, and separated from it by a low rock, are two more small Craters of the same character; they form the base of an isosceles triangle, Taquet being the apex. Another mass of rock intervenes, and we have the eighth Crater from the promontory. These Craters are pretty nearly of the same size, and differ but slightly from Taquet in this respect. The last two are the only Craters of the eight given by Beer and Mädler.

"In Beer and Mädler's map Taquet is given as larger than B. B is fully double the size of Taquet, and A on the south of the high land on which B is situated, and also on the border of the Mare Tranquillitatis, is about the same size as B. A is indicated as the largest on the map."

Schröter marks A (*e*), it is a little larger than Taquet in his delineation.

In connexion with these differences from Beer and Mädler's map, another Crater on the border of the Mare Serenitatis may be specified; it was observed the same evening, and is not indicated on the map. The record of it is as follows:—

"The depression *b*, Beer and Mädler, south-west of Menelaus, is finely marked; there is a Crater nearly north of it *on the wall*, it is larger than either of the previous eight, and is not in Beer and Mädler's map. This Crater is found in Schröter's figures marked *m*, also the shallow depression figured as a *deep* Crater marked *f*, the second instance of this kind which I have met with."

On the 29th of October I have the following notice: "The Craters on the ridge terminated by the Promontorium Acherusia very apparent, the terminating point *bright*."

The almost extreme difficulty of seeing these Craters, as they are visible but for a short time after sunrise—I have not seen them under the evening illumination—will, I apprehend, fully account for their having been omitted by the Selenographers above named. On a suspicion crossing the mind of the darker portions of the south wall of the Mare Serenitatis being the *shadows of cliffs*, I made the following note under date of May 5, 1862:

"The regularity appears to be too great to countenance this idea, the interior illumination is perceptible in that abutting on B of Beer and Mädler, also in the eighth, which is given both by Schröter, and Beer and Mädler, nor do the shadows fall quite in the direction for giving them the character of shadows of cliffs."

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Some other communications received prior to the November Meeting, will be published in the next number of the *Monthly Notices*.—ED.

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### *Minor Planet* (78) *Clytia.*

The Planet was discovered by Mr. Tuttle, at Harvard College, on April 7 (see *Ast. Nach.* Nos. 1368, 1370, 1374). Elements have been computed by Mr. Hall and Mr. Safford; those of Mr. Safford, from observations of April 7, 18, 25, and May 8 and 26, are

Epoch 1862, May $2^d\,0^h$, Washington M.T.

| | | | |
|---|---|---|---|
| L | = | 184° 30′ 53″·6 | Mean Equinox 1860·0 |
| $\pi$ | = | 61 11 13·5 | |
| $\Omega$ | = | 7 32 23·7 | |
| $i$ | = | 2 24 49·6 | |
| $\varphi$ | = | 2 31 14·4 | |
| $\mu$ | = | 13 35·029 | |
| log $a$ | = | 0·425889. | |

### *Minor Planet* (74) *Galatea.*

The discovery of this new Minor Planet by M. Tempel at Marseilles is announced, *Ast. Nach.* No. 1381, where the following positions are given:—

| | h m | h m s | ° ′ ″ |
|---|---|---|---|
| Aug. 29 | 10 | 0 2 32 | +3 55 |
| 30 | 10 30 | 0 2 12 | +3 50 30 |

the planet being of the 11th magnitude. The following are the elements computed by Dr. Frischauf from observations of Sept. 16, 22, and 28.

Epoch, 1862, Sept. 16·0, Berlin M.T.

| | | |
|---|---|---|
| M | = 353° 48′ 52″·9 | Mean Equinox 1363·0 |
| Π | = 6 42 36·5 | |
| Ω | = 200 29 20·2 | |
| $i$ | = 3 15 43·8 | |
| $\varphi$ | = 14 12 26·3 | |
| $\mu$ | = 858″·5920 | |
| Log $a$ | = 0·410813 | |

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### *Minor Planet* (41) *Daphne* ((75)?).

It appears (*Ast. Nach.* Nos. 1380 and 1382) that, at the Bilk Observatory, on the night of Aug. 31st, at about $11\frac{1}{2}^h$, Dr. Luther observed a planet of the 11th magnitude resembling the lost planet *Daphne;* and that, from this observation and two observations of Sept. 5 and Sept. 11, at Berlin, the following elements have been computed:—

Epoch, 1862, Sept. 5·5, Berlin M.T.

| | | |
|---|---|---|
| M | = 88° 51′ 17″·5 | Apparent Equinox at Epoch. |
| Π | = 233 44 39·8 | |
| Ω | = 179 7 7·7 | |
| $i$ | = 14 38 49·4 | |
| $\varphi$ | = 16 47 27·7 | |
| $\mu$ | = 728″·320 | |
| Log $a$ | = 0·458452 | |

which agree so nearly with Dr. Seeling's elements of *Daphne* as to leave no doubt of the identity of the two planets. The planet is however in subsequent numbers referred to as *Daphne* (75).

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The name "*Melete*" instead of *Pseudo-Daphne*, given to the minor planet (56), has not hitherto been mentioned in the *Monthly Notices.*

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OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. XXIII. *December* 12, 1862. No. 2.

Dr. LEE, President, in the Chair.

Lieut. Allen Young, R.N., Riversdale, Twickenham, was balloted for and duly elected a Fellow of the Society.

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## *A Last Letter from Capt. W. S. Jacob.*

(*Communicated by Prof. C. Piazzi Smyth*).

"Having enjoyed the privilege," writes Prof. Smyth, "of receiving frequent letters from my estimable friend, Captain W. S. Jacob, during the whole of his previous career in India as an official astronomer, I hailed with exceeding delight, during last September, the arrival of a first letter, written on his once again returning to the land of his adoption and youth; now as a private astronomer, but with judgment matured, intellect strengthened, his own settled problems to work out, and a far more powerful astronomical instrument than he had ever had an opportunity of observing with before.

"But that first letter was destined also to be his last, for within a week of closing it, he was no more of *this* world. He had served the government previously, but too faithfully, first in a military capacity, and afterwards in the Madras Observatory; and had, as the result has proved, too nearly consumed for them his physical vital energies, while his mind was still active and dominant as ever.

"Capt. Jacob's letters, and his manner too, were never of a demonstrative character; but there was always a quiet worth about them, a calmness of view, sobriety of description, and easy introduction of numerical data, which rendered them of remarkable interest, and occasionally of extreme importance with reference to many scientific questions. These characteristics are all so well marked in his last letter, that I have thought for that reason, as well as because it is the last letter of a good and learned man, that the members of the Royal Astronomical Society might be interested in seeing it, recording it, and judging for themselves. It runs thus,—

"'*Ship Herefordshire, 25th July*, 1862.

"'My dear Smyth,

"'As we approach Bombay I begin a letter to have it ready to despatch on arrival, as I may not have time to write much then. We have had a tolerably pleasant voyage on the whole, the ship being well found and commanded, the party of passengers not too large, so as to incommode each other, and all having pulled pretty well together, so that there have been no quarrels, though a long sea-voyage seldom passes without them. Our freedom from them I attribute, in part, to the absence of *cards*, which often prove a fertile source of dispute.

"'I have been able to do but little in the way of work on the voyage; much less than I expected; there were perpetual interruptions, and though we have met with little or no very severe weather, there has been plenty of it sufficiently rough to prevent our settling to any quiet occupation, and especially the use of the microscope, with which I had hoped to do something. But in this I have quite failed. In the few attempts I have made, I did not succeed in finding any organism in the water at all. How to account for this is a puzzle to me; but I have also remarked that there has been throughout the voyage far less phosphorescence at night, than I remember on any former occasion; on many nights none whatever.

"'On the other leaf are a few memorandums which may interest you; you can make any use of them you please. The S.E. Trade has been irregular and squally on both sides of Africa: on *this* side it has occasionally blown for some hours from E.N.E., or thereabouts. So there have been anomalies in the atmosphere as well as the ocean.

"'*August 7th.* The same remarks will apply to the end of our voyage; when this was commenced we were expecting to reach Bombay in about a week, the passage from the Line being generally pretty rapid at this season, but instead of finding the S.W. monsoon at or near the Line, we met with light baffling winds from S., W., and even N.W., as far at lat. 10° N. For the last three days we have had the monsoon wind, but very little S. of W. We hope to anchor this after-

noon. All well, and in pretty good spirits, though we have been suffering latterly from heat more than I should have expected, the highest temperature having been 85°, but the light winds made it more oppressive. With our kind remembrances to ———,

"'Believe me,

"'Yours very truly,

"'W. S. Jacob.'

"11th August. Anchored on the 7th, at 2h P.M. Leaving for Poona to-morrow morning. All well!

"*Zodiacal Light.*

May 17th, at 8h P.M., in lat. 21° 1′ N. and long. 23° 20′ W.

Zod. light very bright, extending nearly to *Præsepe*.

| | h | m | | ° | ′ |
|---|---|---|---|---|---|
| ∴ apex in R.A. | 8 | 31 | and Decl. + | 20 | 30 |
| and Sun in R.A. | 3 | 37 | and Decl. + | 19 | 25 |

May 26th, at 7h 30m P.M., in lat. 4° 45′ N. and long. 21° 20′ W.

Zod. light reaches nearly to *ι Leonis*.

| | h | m | | ° | ′ |
|---|---|---|---|---|---|
| ∴ apex in R.A. | 9 | 35 | and Decl. + | 24 | 30 |
| and Sun in R.A. | 4 | 13 | and Decl. + | 21 | 12 |

June 11th, 16h 0m, in lat. 14° 44′ S. and long. 32° 15′ W.

Zod. light extends nearly to *Mars*.

| | h | m | | ° | ′ |
|---|---|---|---|---|---|
| ∴ apex in R.A. | 23 | 13 | and Decl. − | 8 | 5 |
| and Sun in R.A. | 5 | 21 | and Decl. + | 23 | 9 |

June 16th, 7h 0m, in lat. 26° 30′ S. and long. 34° 0′ W.

Zod. light extends to a little beyond *Regulus*; axis points nearly to *α Virginis*.

| | h | m | | ° | ′ |
|---|---|---|---|---|---|
| ∴ apex in R.A. | 10 | 5 | and Decl. + | 12 | 30 |
| and Sun in R.A. | 5 | 39 | and Decl. + | 23 | 22 |

June 21st, 7h 0m, in lat. 31° 53′ S. and long. 24° 55′ W.

Zod. light reaches nearly to *Saturn*, a little S.W.

| | h | m | | ° | ′ |
|---|---|---|---|---|---|
| ∴ apex in R.A. | 11 | 16 | and Decl. + | 7 | 0 |
| and Sun in R.A. | 6 | 0 | and Decl. + | 23 | 27 |

July 16th, $6^h\ 40^m$, in lat. 29° 52′ S. and long. 55° 19′ E.

Zod. light seen along with twilight. At $7^h\ 0^m$ the vertex extends to half way between $\gamma$ and $\alpha$ *Virginis*. The light is much paler than the brighter portion of the Milky Way.

| | h | m | | ° | ′ |
|---|---|---|---|---|---|
| ∴ apex in R.A. | 12 | 57 | and Decl. − | 5 | 34 |
| and Sun in R.A. | 7 | 43 | and Decl. + | 21 | 20 |

July 17th, $7^h\ 0^m$, in lat. 28° 11′ S. and long. 57° 40′ E.

Sky hazy; the Zod. light is ill defined, but seems to reach a point about $\frac{1}{3}$ of the way from *Spica* towards $\delta$ *Virginis*.

| | h | m | | ° | ′ |
|---|---|---|---|---|---|
| ∴ apex in R.A. | 13 | 5 | and Decl. − | 7 | 15 |
| and Sun in R.A. | 7 | 47 | and Decl. + | 21 | 10 |

July 22d, $7^h\ 30^m$, in lat. 16° 2′ S. and long. 62° 23′ E.

Sky hazy; Zod. light very indistinct, extremity somewhere about *Spica*.

| | h | m | | ° | ′ |
|---|---|---|---|---|---|
| ∴ apex in R.A. | 13 | 18 | and Decl. − | 10 | 26 |
| and Sun in R.A. | 8 | 7 | and Decl. + | 20 | 15 |

July 30th, $16^h\ 40^m$, in lat. 5° 5′ S. and long. 63° 20′ E.

Zod. light bright; extremity nearly two degrees north of $\alpha$ *Tauri*, noted while *Venus* was behind a thick cloud.

| | h | m | | ° | ′ |
|---|---|---|---|---|---|
| ∴ apex in R.A. | 4 | 28 | and Decl. + | 18 | 15 |
| and Sun in R.A. | 8 | 39 | and Decl. + | 18 | 30 |

"*Other Phenomena.*

"May 21. In lat. 12° 20′ N., long. 25° 0′ W., $\eta$ *Argus* is almost lost in the nebula—quite so to the naked eye. In binocular, it looks a little brighter than $\varepsilon$ *Crucis*, but far below $\delta$.

"June 11. Lunar eclipse: when totally immersed, the Moon was of a dull copper colour, with a silvery edge at the part last immersed.

"July 16. In lat. 29° 45′ S., and long. 55° 25′ E., a large meteor seen at $7^h\ 50^m$, about twice as bright as *Venus*, passing obliquely downwards to the left, a little below *Corona Borealis*. It disappeared and reappeared several times behind small clouds.

"July 17. $\eta$ *Argus* is now scarcely so bright as $\varepsilon$ *Crucis*.

"July 29. Many small meteors at about $15^h$, most of them directed towards a point between *Polaris* and *Capella*, rather

nearer *Polaris!* One, brighter, crosses *Cygnus* from *Cassiopeia.*

"July 30. Many small meteors in various directions between $8^h$ and $9^h$, and again about $16^h\ 30^m$."

Thus closes Capt. W. S. Jacob's last letter to me; wherein, the meteor of July 16th, with its notes of proof of a minimum distance; and the Zodiacal Light of July 30th, with its example of profiting by an accident, to eliminate a dangerous interference with the sort of observation he was engaged on, illustrate most truly the able observer and intelligent mind. I would also, and more particularly, beg to call attention to the extremely anomalous condition which the writer describes, as prevailing both in the sea and atmosphere; the latter evidenced in the perversion of both trade-winds and monsoons: the whole forming a most independent testimony to Sir John Herschel's opinion recently expressed, in the *Memoirs of the Manchester Philosophical Society;* to the effect, that the climate of the whole Earth has been experiencing, for the last two and three years, a remarkable disturbance from a cosmical cause, which he places in the Sun, and traces, first in its direct action on the Southern hemisphere, and then indirect action on the Northern.

In the section of the Zodiacal Light I have added to each observation, in parentheses, a note of the concluded Right Ascension and Declination of the apex of the light, as well as of the Sun, at the time, to facilitate deductions; and amongst the additional phenomena, have only to allude to the striking terms in which my deceased friend describes the decadence of *η Argus.* When I left the Southern hemisphere, in 1845, this star was brighter than any in the Northern hemisphere, and was the third brightest in the Southern, being transcended only by *Sirius* and *Canopus,* if, indeed, the latter was superior. It was then, without doubt, brighter than when Sir John Herschel left the Cape in 1838; but it had increased so much during his stay, that that great astronomer remarked, in a conversation there can now be hardly any blame in reporting, "that he was glad he had mapped down the nebula around *η Argus* during the earlier part of his visit, for that now (in 1837) the star was so bright as to have nearly extinguished the nebula," or words to that general effect. In the year 1862, however, behold Capt. Jacob beginning to describe *η Argus* as, in its turn, "almost lost in the nebula"—a remarkable inversion of the former particulars.

## *Observations of the Horizontal Refraction of the Sun.*

By A. Lang, Esq.

The observations were made on the rising, from the horizon of the Sea, of the Sun's upper or lower limb, or both combined, so as to determine the exact moment of the rising of his centre, and from that the exactly computed zenith distance at that moment, for the purpose of obtaining the refraction, through comparison with the actual zenith distance of the horizon of the Sea, as measured and determined at the place of observation. The place of observation, "my Observatory" in the Island of St. Croix, in lat. 17° 44′ 32″ N., long. 64° 41′ W. from Greenwich; height of the axis of my Altitude and Azimuth circle (Troughton) above the level of the sea, 440 English feet, most carefully measured in every way (tube only a few inches); angle of depression of horizon of the Sea, as determined by the instruments, I have never found less than 20′ 52″, and never beyond 21′, and the last very rarely. I have therefore assumed the angle of depression for the following observations as 20′ 56″, or zenith distance 90° 20′ 56″; the height of my eye in observing the Sun being always at the same height above the Sea-level as the axis of the Circle, but in an adjoining apartment, near my mean-time clock, that I might hear and count the seconds. Telescope used, an excellent 44-inch refractor, using a magnifying power of 42, always previously fixed on the spot where the Sun would rise.

| | Zenith Distance of Sun's Centre. By Computation. | Actual Observation. | Refraction and Parallax. | Barom. Ins. Pts. | Therm. Fahr. |
|---|---|---|---|---|---|
| | ° ′ ″ | ° ′ ″ | ′ ″ | | ° |
| 1831, May 3 | 90 53 25 | 90 20 56 | 32 29 | 29·63 | 76 |
| June 20 | 52 44·8 | ,, | 31 48·8 | ·70 | 73 |
| 1832, June 5 | 52 58·7 | ,, | 32 2·7 | ,, | 79·5 |
| Oct. 27* | 54 4·5 | ,, | 33 8·5 | ,, | ,, |
| 1833, July 31 | 53 11·5 | ,, | 32 15·5 | ·63 | 79 |
| Oct. 31 | 53 6·4 | ,, | 32 10·4 | ·62 | 77·5 |
| Nov. 1 | 52 50·5 | ,, | 31 54·5 | ·53 | 78 |
| 1834, May 3 | 53 11·1 | ,, | 32 15·1 | ·69 | 78 |
| July 11 | 52 57·8 | ,, | 32 1·8 | ·60 | 79 |
| Oct. 25 | 53 6·9 | ,, | 32 10·9 | ·62 | 79 |
| 1837, July 30 | 53 6·9 | ,, | 32 10·9 | ·67 | 78 |
| 1839, May 17† | 90 53 1 | ,, | 32 5 | 29·635 | 77 |

* I am not satisfied with this observation.

† The observation of May 17, 1839, which I have carefully computed, should be more correctly stated 90°53′14″·82 (−90°20′56″ = 32′18″·82). It attracted my notice, as the time was exactly determined by a transit immediately afterwards. It is singular it should so exactly agree with the mean of 17 observations.

| | Zenith Distance of the Sun's Centre. By Computation. | Actual Observation. | Refraction and Parallax. | Barom. Ins. Pts. | Therm. Fahr. |
|---|---|---|---|---|---|
| | ° ′ ″ | ° ′ ″ | ′ ″ | | ° |
| 1840, May 11 | 90 53 47·7 | 90 20 56 | 32 51·7 | 29·64 | 77 |
| 1844, July 30 | 52 56·8 | ,, | 32 0·8 | ·57 | 79 |
| 1846, May 13 | 53 42·4 | ,, | 32 46·4 | ·61 | 79 |
| 17 | 53 37·6 | ,, | 32 41·6 | ·55 | 78 |
| 1848, Feb. 17 | 90 53 22·7 | ,, | 32 26·7 | ·55 | 70 |
| | 17)905 12·8 | | 549 20·3 | 15)92·85 | 16)1240 |
| | 90 53 10·84 | 90 20·56 | 32 18·84 | 29·619 | 77·5 |
| 1857, Oct. 27* | 90 53 25 | ,, | 32 29 | 29·547 | 77·5 |
| 30 | 53 19 | ,, | 32 23 | ·602 | 78 |
| Nov. 1 | 53 22·6 | ,, | 32 26·6 | ·593 | 78·6 |

The altitude of my Observatory above the level of the sea, 440 English feet, causes a depression in the barometer of 0·455 inch.

From my station, the rising of the Sun from the horizon of the sea can only be seen in May, June, July, part of October, November, and February. The setting of the Sun into the horizon of the sea, not at all. Moreover I have sometimes every morning, for six weeks running, watched, disappointed, to get an observation on his rising, in consequence of dense low clouds of cumuli at horizon. To this day I have not obtained a single observation this year. So it is not so easy a matter as may be imagined.

*St. Croix, 11th July*, 1862.

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## *On the Practicability of observing the Occultation of Stars by the Moon at Sea.* By David Smith, Esq.

The author, in his communication addressed to the President and Council of the Society, writes as follows:—

It is not without some degree of hesitation that I take the liberty of forwarding you the results of my own experience as regards the practicability of observing Occultations of Stars at sea. The desire I feel that this most invaluable method for determining the Longitude may come into more general use amongst Naval men will, I trust, be a sufficient apology for my addressing you.

The method, as far as I can ascertain, has been, but with few exceptions, wholly neglected at sea: this has, no doubt, arisen from a supposition that the motion of a vessel would

* "An admirable observation" is added to the observation in my Journal.

prevent using a telescope of sufficient power to observe the phenomena, as the stars most frequently occulted are small. Another reason may be, that a previous knowledge of the star or its relative position to the larger stars is requisite.

With respect to the objection on account of the vessel's motion, I have only to state that except when a ship is very uneasy and laboursome, that stars up to the third magnitude can easily be observed disappearing or reappearing at the Moon's dark limb; and that in smooth water, and the Moon not nearer than three days from the opposition, stars between the fourth and fifth magnitude can be observed with great precision.

As regards the power of the telescope employed, all that is necessary is a good ship's glass, such as are usually sold for 3*l.* or 4*l.* With instruments of this description I have observed ten occultations, which have yielded unexceptionable results. They stand as under:—

| | | | |
|---|---|---|---|
| Disappearance of | * Regulus on the Moon's dark limb. | | |
| ,, | * *b* Ophiuchi | ,, | ,, |
| ,, | * $h^2$ Sagittarii | ,, | ,, |
| ,, | Saturn | ,, | ,, |
| ,, | * $\varphi$ Sagittarii | ,, | ,, |
| ,, | * Antares on the Moon's bright limb. | | |

| | | | |
|---|---|---|---|
| Reappearance of | * Antares on the Moon's dark limb. | | |
| ,, | * $\eta$ Piscium | ,, | ,, |
| ,, | * $\eta$ Tauri | ,, | ,, |
| ,, | * 27 Tauri | ,, | ,, |

The two last-named stars were observed on the same night, and the results agreed to within two seconds of time.

In the case of the star $h^2$ *Sagittarii*, the star seemed to advance upon the Moon's disk before disappearance.

The disappearance of *Antares* on the Moon's bright limb gave a very satisfactory result, as was verified on our arrival at Colombo, Ceylon, some ten days after.

I may add that I have found Captain Shadwell's Tables (for finding the approximate times of beginning and ending) of great assistance, being concise and easy of application, and invaluable for finding the time of reappearance.

In the annexed papers I have given the calculation of the longitude by the Occultations of $\eta$ *Piscium*, $\eta$ *Tauri*, and 27 *Tauri*.

I may also state that I have observed the termination of two Solar Eclipses at sea. The resulting longitudes were very exact. One happened two days after leaving port, and the

other in sight of the Island of Basilan, near Mindanao; so that the chronometer's errors were well known.

By means of the Eclipse of the Sun and the Occultation of the star $\eta$ *Piscium*, carried on by a very steady chronometer, I have during my last voyage been enabled to check the Longitudes of several most important points in the Eastern Archipelago.

*Lavender Wharf, Rotherhithe, S. E.,*
*July 24th, 1862.*

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The following is one of the three calculated Occultations above referred to.

### *Occultation of* $*$ $\eta$ *Piscium by the Moon.*

On board the ship Marchioness, of Londonderry, July 1861, in the Java Sea; latitude 4° 49′·3 south; longitude by account 114° 55′ east. I observed the reappearance of the star $\eta$ *Piscium* on the Moon's dark limb to take place on July 28th, $15^h\,25^m\,8^s$ apparent time at ship. A chronometer showed at the same time, $7^h\,48^m\,46^s$, its assumed error on Greenwich Mean Time being $2^m\,50^s$ slow. Required the longitude of the ship, and the chronometer's error on Greenwich Mean Time by this observation.

| | h m s |
|---|---|
| Time of emersion by chronometer, July 28th | 7 48 46 |
| Chronometer's assumed error, slow..... | = + 2 50 |
| Greenwich date of observation ..... | = 7 51 36 |

at which time we have the Sun's Right Ascension $=8^h\,31^m\,59^s$, Moon's Declination 14° 21′ N., Moon's Equatoreal Horizontal Parallax $=54'\,16''{\cdot}0$, Moon's Semidiameter $=14'\,49''{\cdot}2$, the Star's Right Ascension $1^h24^m6^s{\cdot}17$, Star's Declination $=14°\,37'\,58''{\cdot}6$ N., Reduction of Latitude $-1'\,55''$, log. radius of the Earth at the place $=9{\cdot}99999$.

| | h m s | | ° ′ ″ |
|---|---|---|---|
| Sun's right ascension..... = | 8 31 59 | | |
| Apparent time ..... = | 15 25 8 | | |
| Right ascension of meridian = | 23 57 7 | Latitude..... = | 4 49·3 S. |
| Star's right ascension ..... = | 1 24 6 | Reduct. = − | 1·9 |
| Star's hour-angle in time E. = | 1 26 59 | Geocentric lat. = | 4 47·4 S. |
| $h$ = ,, in arc = | 21 44 45 | | |

☽'s equat. hor. par. log. 3·51268
Log. radius of Earth ... 9·99799

| | | | | | |
|---|---|---|---|---|---|
| Log. reduced parallax | 3·51267 | | 3·51267 | | =3·51267 |
| Latitude, cosine ..... | 9·99848 | sine..... | 8·92161 | cosine ... | =9·99848 |
| ✱'s hour-angle $h$, sine | 9·56876 | ✱'s ☽, cosine | 9·98568 | ✱'s ☽, sine | =9·40248 |
| $p$ = | 3·07991 | K=263″·0=2·41996 | | ($h$), cosine | =9·96846 |
| ☽'s declination, cos | 9·98623 | | K′=−762″·2=2·88209 | | |
| | 3·09368 | K=−263″·0 | | | |
| Constant logarithm..... | 7·92082 | K′=−762·2 | | | |
| Cor. of ✱'s hour-ang. =−10′·34= | 1·01450 | K+K′=−1025·2=cor. ✱'s decl.=17′5″·2 | | | |

| | | | |
|---|---|---|---|
| ✱'s hour-angle | $=h=21\ 44'\cdot75$ | ✱'s declination | $=14^h\ 37^m\ 58^s\cdot6$ N. |
| Correction as above | $-\ 10'\cdot34$ | K+K′−corr. | $=-\ 17^m\ 5^s\cdot2$ |
| ✱'s hour-angle corrd. | $=(h)=21\ 34'\cdot41$ | ✱'s decl. corrd. | $=14^h\ 20^m\ 53^s\cdot4$ N. |

Computation of the first part of the Moon's Parallax in Right Ascension:—

Log $p$ as in the preceding part =3·07991
✱'s corrected declination cos =9·98623
3·09368
Constant logarithm=8·82391
First part of ☽'s par. rt. ascen. log=1·91759=$82^s\cdot72$ or $-1^m\ 22^s\cdot72$

The ☽'s declination at the Greenwich date (corrected for $2^s$ difference) is 14° 20′ 58″·7 N.

Computation of the second part of the Moon's Parallax in Right Ascension:—

✱'s decl. corrected 14° 20′ 53″·4 N.
☽'s declination ... 14 20 58·7 N. } mean=$\beta$=14° 20′ 56″ N.

Diff. = 5·3 ✱ south of the ☽.
☽'s semidiameter = 14 49·2

Sum = 14 54·5=894″·5 log.=2·95158
Diff. = 14 43·9=883″·9 log.=2·94640
$\beta$ =14 20 56 cosec.$^2$=0·02753
2) 5·92551
2·96275
Log 15 constant=1·17609
Second part of ☽'s par. right ascen.=+$61^s\cdot19$ log 1·78666

| | | h | m | s | |
|---|---|---|---|---|---|
| ✱'s right ascension | | 1 | 24 | 6·17 | |
| Part 1st corr. | − | | 1 | 22·72 | (minus because ☽ east of meridian). |
| | | 1 | 22 | 43·45 | |
| Second part | + | | 1 | 1·19 | (plus because an emersion). |
| ☽'s right ascension = | | 1 | 23 | 44·64 | |
| ,, at $7^h$ = | | 1 | 22 | 6·31 | |
| ,, at $8^h$ = | | 1 | 24 | 0·57 | |

| | | | |
|---|---|---|---|
| diff. 98·33 | log..... | = | 1·992686 |
| diff. 114·26 | log (ar. comp.) | | 7·942106 |
| 36″·00 | constant log | | 3·556302 |
| | log = | | 3·491094 |

Correction in time = + 3098ˢ·1

$+51^m38^s.1$

| | h | m | s |
|---|---|---|---|
| Greenwich time ..... | 7 | 0 | 0·0 |
| M.T. at Greenwich = | 7 | 51 | 38·1 |
| Equation of time = − | | 6 | 10·1 |
| App. time at Green. = | 7 | 45 | 28 |
| App. time at ship = | 15 | 25 | 8 |
| Long. in time = | 7 | 39 | 40 |
| Longitude in arc | 114° | 55′ | 0″ E. |

| | h | m | s |
|---|---|---|---|
| | 7 | 51 | 38·1 |
| Chronometer showed | 7 | 48 | 46·0 |
| Chron. slow, G.M.T. = | | 2 | 52·1 |

N.B. An error of 2 miles in the latitude does not affect the result, an error of 10 seconds in the hour-angle of the star or apparent time makes a difference of only $4^s.6$.

The latitude had been deduced from the meridian altitude of ✱ *Schedar*, which happened soon after the occultation, and reduced to that time by the D.R. This was also checked from the preceding and following days' latitudes by the D.R. Allowing for the current, the two results agreed within half a mile.

The apparent time was deduced from four sets of observations of stars E. and W. of the meridian, taken with two different instruments, viz. two sets of ✱ *Aldebaran* E. and two sets by ✱ *Altair* W. These were again checked by observations of the Sun for time after sunrise, and agreed very closely.

Six hours after observing the occultation, we were on the meridian of the east end of the Island of Arentes, in the Java Sea. I then took sight of the Sun and Moon for time, the Sun being east and the Moon west of the meridian. The results showed the chronometer to be

| | h | m | s | |
|---|---|---|---|---|
| | 7 | 41 | 23·5 | slow of the mean time of the place, |
| and the chron.-error being − | | 2 | 52·5 | slow. |
| | 7 | 38 | 31 | |

or the longitude of the east point of Arentes in arc = 114° 37′ 45″ E. of Greenwich.

This agrees nearly with Lieut. Raper's position: he gives the centre of the island $=114^{\circ}\ 37'$. The island extends about three miles E. and W.

Forty-seven lunar distances from the Sun, viz. 31 W. and 16 E., gave the chronometer an error of $2^{m}\ 51^{s}$ slow at the time of occultation, which would assign nearly the same value for the longitude of the island as given above.

The chronometer had a steady rate of $1^{s}\cdot6$, losing for about seventy days.

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*On the Variable Star* R *Vulpeculæ.* By G. Knott, Esq.

From a comparison of my own observations with Mr. Pogson's useful Ephemeris, I had been led to suspect some irregularity in the period of this star, and in a short paper, which was printed in the last volume of the *Monthly Notices*, I communicated my suspicions to the Astronomical Society. The paper appears to have come under the notice of Dr. Winnecke of Pulkowa, who, by his observations and researches, may almost be said to have made the star his own, and in a letter to the Rev. R. Main (*Monthly Notices*, vol. xxii. No. 8), adverting to the subject he remarks that he was afraid that an error of transcription had crept into the elements he communicated to Mr. Pogson, and proceeds to give his definitive epoch and period founded on "seven maxima, observed in the course of three years, with reference to Piazzi's estimations of magnitude in August 1803," together with an Ephemeris for the years 1861, 1862. My own observations of two maxima present so fair an accordance with Dr. Winnecke's predictions, that I venture to submit them to the Society, in the hope that they may possess some interest. My final results are as follow:

Observed maxima of R *Vulpeculæ*, 1861, December 30·5, mag. = 8·7. 1862, October 4, mag. = 8·2, being later than the calculated dates by $3\frac{1}{2}$ and 4 days respectively, a difference which may *possibly* be due to *personal equation*. The period deduced from these observations, viz. 138·75 days, presents also a very satisfactory agreement with that given by Dr. Winnecke, and I think we may fairly infer that R *Vulpeculæ* belongs to the class of regular variables.

*Woodcroft Observatory, Cuckfield,*
*November 17th, 1862.*

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*Description of a New mode of obtaining the Value of the Divisions of a Transit Level.* By Capt. W. Noble.

I have recently been occupied in re-determining the value of the divisions of my Transit Level, by a method which, while

it involves no new principle, is, I believe, in detail perfectly original.

The Level, the value of whose divisions was to be determined, was in the first place lashed securely to the declination circle of my Equatoreal. The micrometer having been screwed into the eye end of the telescope, the wires were separated by some known number of seconds of arc. The instrument being now firmly clamped in the meridian, the telescope was so adjusted that a star not very far from the equator should, during its transit, run along and be threaded by the *top* wire of the micrometer. Just before the star entered the field the level was carefully read. As the star approached the middle of the field the telescope was depressed by means of the tangent screw of the declination circle, until the star ran along the *bottom* wire of the micrometer, whereupon the level was again read immediately. The number of seconds of arc through which the telescope, declination circle, and level, had been moved, was of course that of the interval between the micrometer wires, and this, divided by the number of divisions passed over by the level bubble, gave the value of one division.

The possessor of a large meridian circle would doubtless find that the ordinary mode of lashing his level to this circle and of reading the arc passed over by means of the circle microscopes, would be more accurate and expeditious; but to those who like myself possess only an Equatoreal, I would commend my method as susceptible of very considerable precision.

I may, in conclusion, mention merely as a fact, without attempting to account for it, that I invariably obtained a larger value for the divisions of the level scale from daylight observations, than I did from those made at night.

*Forest Lodge, Maresfield, Sussex,*
*November 12th, 1862.*

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## *Results of the Meridional Observations of Small Planets; Occultations of Stars by the Moon; and Occultation of Jupiter's Second Satellites; observed at the Royal Observatory, Greenwich, in October and November, 1862.*

(*Communicated by the Astronomer Royal.*)

### *Themis* (24).

| Mean Solar Time of Observation. | | R.A. from Observation. | N.P.D. from Observation. |
|---|---|---|---|
| | h m s | h m s | ° ′ ″ |
| 1862, Oct. 29 | 13 3 52·2 | 3 36 15·10 | 70 21 4·09 |
| Nov. 27 | 10 46 17·8 | 3 12 38·23 | 71 40 47·37 |

## *Iris* (7).

| Mean Solar Time of Observation. | | R.A. from Observation. | N.P.D. from Observation. |
|---|---|---|---|
| | h m s | h m s | ° ′ ″ |
| 1862, Oct. 3 | 9 57 43·1 | 22 47 5·02 | 86 16 41·77 |
| 9 | 9 31 39·9 | 22 44 36·92 | 86 54 20·02 |
| 10 | 9 27 26·6 | 22 44 19·41 | 87 0 17·11 |
| 11 | 9 23 14·9 | 22 44 3·59 | 87 6 8·46 |
| 14 | 9 10 53·1 | 22 43 29·46 | 87 22 56·42 |
| 16 | 9 2 49·2 | 22 43 17·35 | 87 33 26·04 |
| 18 | 8 54 54·2 | 22 43 14·12 | 87 43 17·15 |
| 24 | 8 32 1·9 | 22 43 57·37 | 88 8 53·89 |
| 29 | 8 13 58·5 | 22 45 33·81 | 88 24 59·68 |
| 31 | 8 7 0·2 | 22 46 27·44 | 88 30 1·89 |
| Nov. 3 | 7 56 48·3 | 22 48 3·55 | 88 35 58·61 |
| 10 | 7 34 9·2 | 22 52 56·64 | 88 42 33·16 |
| 12 | 7 27 57·7 | 22 54 37·17 | 88 12 34·85 |
| 17 | 7 12 59·5 | 22 59 19·34 | 88 38 56·13 |

## *Pomona* (32).

| Mean Solar Time of Observation. | | R.A. from Observation. | N.P.D. from Observation. |
|---|---|---|---|
| | h m s | h m s | ° ′ ″ |
| 1862, Oct. 3 | 11 29 51·4 | 0 19 28·51 | 82 54 34·44 |
| 18 | 10 19 41·1 | 0 8 14·99 | 84 39 36·75 |
| 20 | 10 10 33·4 | 0 6 58·84 | 84 52 46·23 |

## *Aglaia* (47).

| Mean Solar Time of Observation. | | R.A. from Observation. | N.P.D. from Observation. |
|---|---|---|---|
| | h m s | h m s | ° ′ ″ |
| 1862, Oct. 3 | 11 55 31·7 | 0 45 12·98 | 83 57 44·08 |
| 24 | 10 16 19·6 | 0 28 32·23 | 85 4 20·05 |

## *Ausonia* (68).

| Mean Solar Time of Observation. | | R.A. from Observation. | N.P.D. from Observation. |
|---|---|---|---|
| | h m s | h m s | ° ′ ″ |
| 1862, Oct. 14 | 8 20 7·1 | 21 52 35·07 | 101 28 58·68 |
| 16 | 8 12 37·8 | 21 52 57·65 | 101 22 50·13 |

All the observations of N.P.D. have been corrected for refraction and parallax.

## *Occultations of Stars by the Moon.*

| Day of Observation. | Phenomenon. | Moon's Limb. | Mean Solar Time. | Observer. |
|---|---|---|---|---|
| 1862. | | | h m s | |
| Oct. 11 | $\kappa'$ Tauri, disapp. | Bright | 13 32 56·2 | E. |
| 11 | $\kappa'$ Tauri, reapp. | Dark | 14 54 18·6 | M.D. |

The initials E. and M. D. are respectively those of Mr. Ellis and Mr. Dolman.

On Nov. 24, Mr. Roberts observed the Reappearance after Occultation of *Jupiter's* Second Satellite. The last contact took place at $18^h\ 27^m\ 20^s{\cdot}4$ G.M.T.

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The *Ann Arbor Astronomical Notices*, No. 28, contains a paper by Truman Henry Safford, Assistant at the Observatory of Harvard College, on the Proper Motion of *Sirius* in Declination.

The author in the first place refers to a paper by Dr. C. A. F. Peters, in the *Astronomische Nachrichten*, Nos. 745, 746, 747, on the Proper Motion of *Sirius* in Right Ascension; in which, by first comparing the observed Right Ascensions of $\alpha$ and $\beta$ *Orionis* in different years with the tabulated Right Ascensions in the *Tabulæ Regiomontanæ*, and thence inferring the corrections to be made to observed places (a process which amounts to the same as supposing that the tabulated Right Ascensions are correct, or subject only to constant error), and applying those corrections to the observed Right Ascensions of *Sirius*, and comparing the corrected observed Right Ascensions of *Sirius* with the tabulated Right Ascensions of *Sirius* in the *Tabulæ Regiomontanæ*, a series of irregularities in the Right Ascensions of *Sirius* are found, which are numerically represented by the following hypothesis. That *Sirius* revolves in an elliptic orbit, on the law of gravitation, round an invisible companion; the time of passing the lower apse being the year 1791·431, the mean yearly motion $7^\circ{\cdot}1865$ (or periodic time 50·01 years), and the excentricity 0·7994: so that, putting $u$ for the excentric anomaly at any time, the mean anomaly or $7^\circ{\cdot}1865\ (t - 1791{\cdot}431)$ will be equal to $u - 0{\cdot}7994 \cdot \sin u$ (from which equation $u$ is to be found); and the correction to the tabular place of *Sirius* will be

$$0^s{\cdot}127 + 0^s{\cdot}00050 \cdot (t - 1800) + 0^s{\cdot}171 \cdot \sin (u + 77^\circ\ 41');$$

where $0^s{\cdot}127$ is a constant correction to the tabular Right Ascension, $0^s{\cdot}00050$ is a correction to the annual variation, and $0^s{\cdot}171$ and $77^\circ\ 44'$ are constants depending on the magnitude of the major axis, its position, the position of the line of nodes of the orbit on the celestial sphere, and the inclination of the orbit to the celestial sphere.

The author then proceeds to treat the irregularities in the Declination of *Sirius* in the same manner. He uses the observations of Bradley (omits those of Maskelyne and Pond before 1822, because the thermometer coefficient is erroneous and he has not re-reduced the observations), uses Bessel 1820, Pond 1822, Struve 1824, Argelander 1830, Taylor 1832·5, Henderson (Cape) 1833, Maclear (Cape) 1834, Airy (Cam-

bridge), Henderson (Edinburgh), Airy (12 year), Airy (6 year), Airy (later results), Busch (*Astr. Nach.* No. 422), Bond 1843, Moesta. Piazzi is omitted, as not sufficiently accurate. The author supports the exactitude of Bradley's result by comparison with Lacaille (1750) and Mayer (1756).

The stars of comparison employed are *α Virginis*, *α² Libræ*, *α Scorpii*, *α² Capricorni*. The tabular places are altered, when necessary, so as to introduce the constant of nutation 9″·22, instead of 8″·98 as in the *Tabulæ Regiomontanæ*, or 9″·65 as in the *Fundamenta Astronomiæ*.

The resulting irregularities in the declination of *Sirius*, now to be explained, are the following:—

| | ″ | | ″ | | ″ |
|---|---|---|---|---|---|
| 1755 | −0·70 | 1833 | −1·48 | 1843 | +1·11 |
| 1820 | −0·40 | 1834 (A) | −2·38 | 1844·5 | +1·86 |
| 1822 | −1·48 | 1834 (M) | −1·71 | 1850·8 | +2·06 |
| 1824 | −1·63 | 1837 | −0·76 | 1855 | +0·82 |
| 1830 | −0·96 | 1838·5 (A) | −0·39 | 1856·5 | +1·53 |
| 1832·5 | −1·68 | 1838·5 (B) | −0·42 | | |

No correction to mean places and mean annual variation destroys the periodicity of those terms, or even reduces the sum of squares of errors in a greater degree than from 33 to 25.

The author then proceeds to try the effect of introducing the same hypothesis as that found by M. Peters from the Right Ascensions; adopting the supposition of elliptic orbit, using the same time of passage of apse and the same excentricity, and determining the two constants still undetermined from comparison of the irregularities with the following formula:—

$$w + x\,(t - 1800) + y\,.\,\sin u + z\,.\,\cos u,$$

and finally obtains

$$0''{\cdot}56 + 0''{\cdot}0202\,(t - 1800) + 1''{\cdot}47\,.\,\sin u + 0''{\cdot}51\,.\,\cos u.$$

By introduction of this formula, the sum of squares of errors is reduced to one-eighth part of the least possible amount on the hypothesis of uniform motion.

It would seem, therefore, that great probability attaches to the hypothesis that, in the system of which *Sirius* is the only visible part, there is a large invisible mass present.

The greatest defect in the series of observations here treated is the lacuna between 1755 and 1820. A large part of this, perhaps, can never be supplied. The unfortunate introduction of Graham's quadrant destroys our confidence in the greater part of Bradley's results, and in Olufsen's corrections for the quadrant in subsequent years (which depend on Bradley). If, however, Bradley's later observations could be

plausibly corrected, the observations of Maskelyne, treated by the method of comparison-stars, would give good instrumental results. No uncertainty, such as is produced by wearing of centre-work of the quadrant, attaches to Piazzi's or Pond's observations.

The correction of the refractions would be no very great work.

On the whole, we could wish that the able author of this paper could be induced to give to it all the completeness which existing materials can enable him to give. G. B. A.

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*On the Forms of Lenses proper for the Negative Eye-pieces of Telescopes.* By G. B. Airy, Esq., Astronomer Royal.

In the *Monthly Notices* for June and November last, there are discussions on the forms of lenses proper for the Negative Eye-piece. Perhaps I shall not do wrong in stating to the Society that as long ago as the year 1827 I made a most elaborate investigation of the properties of Eye-pieces as depending on the curvatures of their surfaces. The paper is entitled "On the Spherical Aberration of the Eye-pieces of Telescopes," and is printed in the *Transactions of the Cambridge Philosophical Society*, vol. iii. This paper had been preceded by one "On the Chromatic Aberration of the Eye-pieces of Telescopes," from which I had been able to infer the proportions of the focal lengths and intervals of the lenses, which (independently of their curvatures) destroy colour at the sides of the field, using but one kind of glass; and had selected some of these as examples to which the formulæ for Spherical Aberration were to be applied. One of these is the Huyghenian Eye-piece, with the following very common proportions:— Focal length of first lens or field-glass = 3 M; focal length of second lens or eye-glass = M; interval between the two lenses = 2 M.

The principal results as applying to the cases before us are the following:—

First, as regards Distortion.

I must refer to page 15 of the Memoir for the general formula; but I may quote the following special results:—

(*a*.) It is possible to destroy Distortion entirely, but not by the use of common forms (equi-convex or plano-convex).

(*b*.) The most favourable combination of common lenses is,—the first, equi-convex; the second, plano-convex, with its convex side toward the first lens, or with its plane side next the eye.

Second, as regards Indistinctness at the edge of the field.

From the general formulæ in page 35 it appears that it is

impossible in any eye-piece whatever, in which the lenses are all convex, to secure distinctness in the approach to the edge of the field, except, in some cases, by movement of the eye-piece; and the problem always is to diminish the Indistinctness as much as possible. For this purpose, in the Huyghenian eye-piece,

(*c.*) The different points of the image may be made distinct by a little sliding of the eye-piece, by a form very nearly the same as the following:

(*d.*) The best form is, for the field-glass, a meniscus, with convex side towards the object-glass, and radii as 4 : 11; and for the eye-glass a convex lens, the mere convex side towards the field-glass, and radii as 1 : 6. The constants by which the indistinctness in the two dimensions is expressed are $\frac{95}{126}$ and $\frac{61}{126}$.

(*e.*) The best combination of common lenses is, two plano-convex-lenses, the plane sides of both towards the eye. The constants of indistinctness then are $\frac{133}{126}$ and $\frac{175}{126}$.

(*f.*) For a single lens to produce the same power, the smallest values of constants of indistinctness would be $\frac{196}{126}$ and $\frac{476}{126}$.

The following rule, though not strictly accurate, will be found sufficiently accurate to give a very good practical determination of the curvatures of all eye-piece lenses in all cases. Trace the course of an excentric pencil through the eye-piece. Consider separately the convergences, &c. of the axis of the pencil with regard to the axis of the telescope, and that of the rays of the pencil with regard to the axis of the pencil. When both these convergences fall on one side (as in the Huyghenian field-glass) the lens ought to be meniscus. When they are at equal distances on opposite sides, the lens ought to be equi-convex. When the convergence of either is much nearer (the other being on the opposite side), the side of the lens next it ought to be plane.

1862, *December* 10.

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At the November Meeting the Astronomer Royal gave an interesting *vivâ voce* account of some investigations which have been recently made to improve our knowledge on the Measures of the Earth and of the Heavens.*

The first part of the Astronomer Royal's Address was

* I am indebted for this article to J. N. Lockyer, Esq., Fellow of the Society, who has kindly undertaken to supply reports of *vivâ voce* communications at the Meetings. — Ed.

illustrated by a map of Europe, on which had been inserted, by hand, the principal lines of triangulation of the countries already surveyed, and also the positions of several towns in Russia which had been obtained after the manner of a ship at sea. A glance at this map rendered evident the fact that the triangulation from the Danube to the North Cape on the North, and from the middle of Russia to Valentia Island on the West, left little to be desired.

Referring to the first labours of the French in the last century, and those of the French, Russians, and Swedes in the present century for the measures of different *Arcs of Meridian*, the Astronomer Royal observed that Russia has taken the lead in the geodetical operations at present in question—the measurement of an *Arc of Parallel.*

This arc, extending from Valentia on the West to the town of Orsk, situated in the extreme East of European Russia, and in nearly the same latitude as Valentia, comprises nearly seventy degrees of longitude, and is, as remarked by the Astronomer Royal, perhaps the longest one that will ever be measured by man.

It was pointed out, by means of the map, that this project of the elder Struve's, which was warmly taken up by the different Governments, by no means required the measurement of the entire arc: the existing triangulation, extending (as before remarked) from Valentia to a point pretty well advanced, would only require linking together where gaps existed, and extending eastward to Orsk.

To derive the measure of the Earth from these operations, it was first necessary to find, by some lineal measure, the *length of this arc;* in other words, to find the *distance in yards* (our standard measurement) between Valentia and Orsk; and, secondly, *the difference of the local times* at the two stations.

First, as to the length of the arc. The British part of it required little attention, as (thanks to the admirable work of the Ordnance Surveyors and subsequent investigation) the actual distance from Valentia to Dover is certainly known to within a few yards. Unfortunately the distance from Dover to Paris (equally well known) will not serve us, Paris being too far south. It became necessary, therefore, to effect a junction with the continental triangulation at some more northerly point; and this has been admirably effected, during the present year, by Sir H. James.

The whole distance from Valentia to some station well advanced is by this time computed, while the triangulation itself is fast approaching Orsk.

Secondly, as to the differences of local time at Valentia and Orsk. This, in an arc of such magnitude, can only be obtained from the differences of local times at intermediate stations in the arc; as, for instance, between Valentia and

Greenwich, Greenwich and Brussels, &c.; and in these determinations, as suggested by the illustrious projector of the operations, railways and telegraphs must be freely taken advantage of.

The difference of local times at Valentia and Greenwich was, as is well known, the subject of elaborate inquiry, some years ago, when several transmissions of chronometers were undertaken between the two places. The results obtained on this occasion have recently been confirmed in a remarkable manner, a complete electric circuit between the two places having been placed at the disposal of the Astronomer Royal by Sir Charles Bright. The difference of times obtained by the electric current (which, it may be stated *en passant*, took one-tenth of a second to traverse the 800 miles of wire) *agreed exactly* with that obtained from the chronometric expedition.

The second part of the Address related to the dimensions of the Solar System.

The recent researches into the velocity of light by means of the turning mirror — an instrument which, as used by M. Foucault, renders this velocity, inconceivable though it be, measurable by a cabinet experiment — and the parallax observations of *Mars*, which have been made during the autumn of this year in both hemispheres, were alluded to by the Astronomer Royal as affecting the determination of the Sun's distance, the unit of all measures of the Heavens.

The smaller velocity of light announced by M. Foucault was shown to necessitate a decrement of the Sun's distance, the two being connected by aberration; for as the umbrella of him who is caught in a shower inclines to meet the rain at a certain angle which depends upon the relative velocity of the rain-drops and the rate at which he is walking, so does the telescope point in advance of the star at a certain angle dependent upon the relative velocities of the light which enters it and the Earth which carries it.

This angle shows that the Earth travels (speaking in round numbers) 10,000 times more slowly than light. If, therefore, it is established that the received velocity of light must be diminished, the diameter of the Earth's orbit, which satisfies the received velocity, must be decreased in the same proportion.

The Sun's parallax, $8''{\cdot}5776$, deduced from the transits of *Venus* in 1761 and 1769, has also been called in question by M. Le Verrier, on other considerations; and the extreme doubtfulness of some of the most important observations of the transit of 1769 renders the success of those of the planet *Mars* doubly desirable; and although, by the latter method, the Sun's distance is only *indirectly* obtained (that of *Mars* resulting *directly* from the observations), the distances are *bound* together by a proportion which, as remarked by the

Astronomer Royal, was accurately known in the times of Copernicus and Tycho as at present.

There is reason to hope that the attempt of the present year will be attended with success. A fair number of eastern and western observations for the independent determinations have been obtained at Greenwich, and more are expected from Madras and Williamstown; and the meridian observations of Polar Distance (which require the co-operation of northern and southern observers) have been undertaken with vigour at all the Observatories of both hemispheres.

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The Astronomer Royal also exhibited an original drawing of the fringes of light formed on a wall immediately before the disappearance of the Sun in the Total Eclipse of 1861, Dec. 31, prepared by a French officer, M. Poulain, Capitaine du Génie, at Goree.

In the accounts of the Eclipse of 1842 collected by M. Arago, and in those of the observers of later eclipses, it has been stated that in the last seconds before total obscuration there is a strange quivering of light upon the ground, &c., like the flitting of small shadows. The Astronomer Royal, in returning from his observing-station in Spain after the Total Eclipse of 1860, July 18, was accompanied in one journey by our Medallist, M. Goldschmidt (an excellent linguist), and by a Spanish gentleman who had observed the eclipse without instruments. This gentleman had been much struck by the sight of the flitting shadows; but, in the conversation which the Astronomer Royal held with him through the interpretation of M. Goldschmidt, it did not appear that the observations were made with such accuracy as to give useful information on the phenomenon.

On the occasion of the Total Eclipse of 1861, Dec. 31, M. Poulain, Capitaine du Génie in the French army, found himself at Goree, with the charge of observing the eclipse if possible; but without telescope or other instruments of the slightest accuracy. With great judgment, he applied himself to make the best use in his power of the means at hand. Meteorological observations of several classes were made with care, and recorded in a most orderly form; on these, however, the Astronomer Royal did not then insist, but proceeded to the depiction of the fringes, which M. Poulain had very carefully observed. The Sun was shining on a vertical white wall directed from east to west, and on this wall, a very short time before the totality (*un instant avant l'occultation*), the fringes were seen; and they were subsequently drawn by M. Poulain in their exact size (*en vrai grandeur*) on the sheet then exhibited. The only account of them given in the detailed record

is, "On voit des franges noires se dessiner sur le mur qui borde notre terrasse." The drawing exhibits five bands; three white, and two dusky-dark, each 4 inches broad; and their form seems to imply that in the longitudinal direction their length was considerable, and that in the lateral direction the repetition was more frequent. Their inclination to the vertical is about 45°; the right-hand end, referred to the hand of a person who is looking at the wall with his back to the Sun, being the lower.

At the Astronomer Royal's request, Mr. Hind was so good as to calculate the position of that point of the Sun's disk which was the last to disappear. It was at 31° from the Sun's vertex towards the east, or towards the left hand of an observer whose face was turned to the Sun. On comparing this with the position of the fringes, as depicted by M. Poulain, and referring the latter roughly to the direction of the Sun's rays, it appears that we may state, with as great accuracy as the observation permits, that the length of the fringes was in the same plane as the tangent to the disks of the Sun and Moon at the place of last disappearance.

The first impression from these appearances is, that they are diffraction-fringes; but the possibility of this explanation would seem to be destroyed by the consideration that any diffraction-fringes must travel with a linear velocity equal to the Moon's linear velocity, and must therefore be totally invisible. The phenomenon is one which deserves the careful attention of observers and optical philosophers. Meantime we may congratulate ourselves that we have for the first time a representation of this singular appearance aspiring to the character of reasonable accuracy. G. B. A.

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*Extract of a Letter from Herr A. Auwers to the Astronomer Royal, dated 5, Gartenstrasse, Gotha, 1861, December 1.* —(Translation.)

Perhaps it is not uninteresting to you to know the result of researches on Parallaxes [of Stars] which I have carried out during the last two years at Königsberg. It is known that Struve, from observations with the Pulkowa Refractor for the parallel of 61 *Cygni*, has obtained a much larger value than Bessel had found with the Königsberg Heliometer, namely, $0''{\cdot}5107 \pm 0''{\cdot}0282$, instead of $0''{\cdot}366 \pm 0''{\cdot}012$. For that reason, I have effected a new determination with the Heliometer, in which I have made use of two comparison-stars different from those used by Bessel, which permit the application of the principle of differences in the most direct manner possible.

From observations on 62 days between 1860 September and 1862 June, I have obtained

Parallax of 61 Cygni = + 0″·5656 ± 0″·0158.

The difference of this determination from Struve's is scarcely greater than its mean error. The mean from both is,

Parallax of 61 Cygni = + 0″·5526 ± 0″·0138;

greater than Bessel's determination by 0″·19.

Another star whose parallax I have determined is the star with large proper motion lately discovered by Prof. Argelander namely, Lalande 21258. This star (of the 8.9 magnitude) have compared on 64 days, from 1860 November to 1862 Ju.. by means of the Heliometer, with one star (of the 8 magnitude) preceding it by $4^m\ 11^s$ and with one star (of the 9 magnitude) following it by $3^m\ 56^s$; and from the differences of observed distances I have found

Parallax of Lalande 21258 = + 0″·2622 ± 0″·0109,

relative to the mean of the two comparison-stars; or absolutely, in conformity with the determinations of Professor Peters,

Parallax of Lalande 21258 = + 0″·2709 ± 0″·0112.

[*Note by the Astronomer Royal.*—The proportion of the discordance of the determinations of the same element, by different observers, to the magnitude of the probable error which each has assigned, throws great doubt upon the validity of such determinations of probable error.]

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In a letter, dated Dublin, Nov. 12, 1862, Mr. Stothard notices the extraordinary brightness of *Aristarchus*, seen by him as a bright speck on the Moon's disk, that morning about $10^h\ 30^m$ A.M. Mean Dublin Time, in bright sunlight.

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Mr. Grove, in a letter, dated Upper Harley Street, 5 Nov. 1862, gives an account (illustrated by three pencil sketches) of the appearances presented by the planet *Mars* on Oct. 26 and 31, and Nov. 3: the telescope used was $4\frac{1}{2}$ inches aperture; focal length 6 feet 2 inches; object-glass by Cooke, of York, capable of dividing $\gamma$ *Coronæ*. He is perfectly satisfied of there being notable changes in the distribution of the lights and shadows, inconsistent, it appears to him, their being land and water, or, as he should perhaps say, land and water *only:*

clouds condensed over large aqueous districts might possibly account for the changes observed; the changes of position by axial revolution would not explain them.

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A paper has been received from Prof. A. D. Wackerbarth, "On the Motion of a Pendulum with especial reference to the Foucaultian Experiments." The greater part of the paper is occupied in the investigation of the equations of motion, which are carefully and elegantly worked out; but the integration of them is developed only so far as to give the ordinary approximate result of a rotation of the plane of oscillation, with a velocity proportional to the sine of the latitude.

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A paper by Mr. Wray, "Observations on *Saturn*," will be published in the following Number of the *Monthly Notices*.—ED.

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In a letter dated Hamilton College Observatory, Clinton, N. Y., 1862, Nov. 24, addressed to the Astronomer Royal, Dr. C. H. F. Peters gives, for Minor Planet ⑰ *Feronia*, the following elements, which are slightly different from those communicated to the *Ast. Nach.* (under the date Nov. 12, see No. 1396):—

Epoch 1862, Dec. 31·0 Greenwich M.T.

| | | | | | |
|---|---|---|---|---|---|
| $M_0$ | = | 73 | 4 | 56·48 | |
| $\pi$ | = | 309 | 48 | 37·93 | Mean Eq. 1863·0. |
| $\Omega$ | = | 207 | 37 | 13·11 | |
| $i$ | = | 5 | 25 | 55·22 | |
| $\varphi$ | = | 6 | 41 | 17·06 | |
| $\mu$ | = | 1034″·0617 | | | |
| Log $\mu$ | = | 3·0145464 | | | |
| Log $a$ | = | 0·3569735 | | | |

(The planet 12-11th magnitude.)

And he gives notice of another new asteroid, which he saw first 12th November and last 23d November; on both which evenings, however, it was clear only for so short a time that he could not determine the position accurately. A good observation (the only one then obtained) was

| | H. C. Mean Time. | R.A. | Decl. | |
|---|---|---|---|---|
| Nov. 15 | $7^h\,26^m\,30^s\cdot3$ | $0^h\,2^m\,8^s\cdot93$ | $+\,1^\circ\,27'\,12''\cdot2$ | (6 comp.) |

The magnitude of the planet was about 11·7. The places on the other days mentioned differed from that of the 15th about thus:—

| | | | | |
|---|---|---|---|---|
| | s | | ′ | ″ |
| Nov. 12 | 0·6 | less in R.A. | 1 49 | further South. |
| ,, 23 | 19 | more in R.A. | 21 40 | further North. |

these motions being taken only by measurement from the chart.

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## *Comets III. and IV.* 1862.

(*Letter from Dr. Bruhns.*)

"*Leipzig, 6 Décembre*, 1862.

"Je me permets de vous envoyer des éléments et des éphémérides des deux comètes qui peuvent servir à faciliter leur observation. Les éléments de la première comète sont calculés par M. Engelmann au moyen des observations des 1, 2, et 3 Décembre, ceux de la 2e comète par moi-même au moyen des observations des 1, 2, et 4 Décembre.

| | Eléments de la 1e Comète (Mouvement rétrograde). | Eléments de la 2e Comète (Mouvement rétrograde). | |
|---|---|---|---|
| | Temps de Berl. | Temps de Berl. | |
| Passage au Périhélie | 1863, Fév. 1·708 | 1862, Déc. 31·1959 | |
| | ° ′ | ° ′ ″ | |
| Longitude du Périhélie | 34 18·5 | 128 12 55·3 | Equinoxe 1863·0. |
| ,, du Noeud | 114 31·0 | 358 16 11·5 | |
| Inclinaison ... | 86 59·5 | 48 22 23·3 | |
| Log. de la Dist. Périhélie | 9·85124 | 9·935674 | |

*Ephéméride de la* 1e *Comète pour* 0h *Temps Moyen de Berlin.*

| | R.A. | Decl. | Log Δ. | Eclat. |
|---|---|---|---|---|
| | ° ′ | ° ′ | | |
| 1862, Nov. 30 | 157 39·8 | − 3 19·2 | 0·0124 | 1 |
| Déc. 4 | 160 39·0 | − 1 33·0 | 9·9601 | ,, |
| 8 | 164 16·9 | + 0 48·1 | 9·9021 | 1·7 |
| 12 | 168 54·8 | + 4 1·0 | 9·8378 | ,, |
| 16 | 175 4·6 | + 8 26·8 | 9·7676 | 3·1 |
| 20 | 182 30·7 | +14 32·9 | 9·6945 | ,, |
| 24 | 196 14·7 | +22 27·1 | 9·6296 | 5·8 |
| 28 | 214 15·3 | +31 0·0 | 9·5912 | ,, |
| 1863, Jan. 1 | 236 48·9 | +36 56·9 | 9·5980 | 6·7 |
| 28 | 305 30·6 | +23 51·2 | 9·9995 | 1·1 |

*Ephéméride de la 2e Comète pour 0h Temps Moyen de Berlin:*

| | R.A. | Decl. | Log Δ | Eclat. |
|---|---|---|---|---|
| | h m s | ° ′ | | |
| 1862, Nov. 30 | 20 59 59·9 | −12 56·4 | 0·2153 | 1 |
| Déc. 4 | 20 9 13·6 | −15 39·7 | 0·1853 | „ |
| 8 | 20 9 29·7 | −18 48·4 | 0·1520 | 1·5 |
| 12 | 20 9 50·1 | −22 58·4 | 0·1068 | „ |
| 16 | 21 0 18·1 | −26 55·5 | 0·0750 | 2·5 |
| 20 | 21 0 58·8 | −32 17·7 | 0·0314 | „ |
| 24 | 21 2 2·5 | −38 54·3 | 9·9854 | 4·0 |
| 28 | 21 3 49·8 | −47 3·8 | 9·9394 | „ |
| 1863, Jan. 1 | 21 7 13·0 | −57 0·7 | 9·8975 | 6·2 |
| 28 | 1 5 31·6 | −45 25·6 | 0·0043 | 2·8 |
| Fév. 17 | 2 0 7·2 | −24 40·8 | 0·2091 | 0·8 |

"Tandis que la première comète sera visible dans nos observatoires boréals, l'autre disparait déja au milieu de Décembre par suite de sa déclinaison australe, mais elle va reparaître probablement au milieu de Février."

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*A few Notes on Prof. C. P. Smyth's Experiences with the Elchies Refractor.* By the Rev. W. R. Dawes.

In the interesting account given by Professor C. Piazzi Smyth in the *Monthly Notices* for November last of his "Experiences with the Elchies equatoreally mounted Refractor of 11 inches aperture," he refers to a group of stars, of which P. i. 222, is the brightest, as having very surprisingly varied in their magnitudes since they were measured by his Father in 1834, in whose "Cycle" they form No. 78. This led me to give them an early examination; and I was astonished to find that no perceptible variation had taken place. On comparing the object presented to my view in my $8\frac{1}{4}$-inch refractor, with a power of only 94, with the Professor's account of it and with Admiral Smyth's measures, I immediately perceived that the Elchies Refractor had not shown the star B at all!—which is the more surprising as it was obvious enough in my telescope at the first glance with so low a power. Moreover, in the "Cycle" there is a transposition of the magnitudes and colours of A and D,—the latter being P. i. 222, a star rather below the 6th magnitude. This mistake, combined with the absence of B in his telescope, has led the Professor to surmise a total change in the group. The three stars to the south of P. i. 222, form the triple star Σ 196; and the fol-

lowing comparison of magnitudes, position, and distances will show that all the components are *in statu quo*:—

Σ 196; $\alpha = 1^h\ 51^m\ 59^s{\cdot}5$; $\delta = +20^\circ\ 20'\ 32''$; Epoch 1863·0.

| Magnitudes. | | | | Positions. | | | | | Distances. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Σ. | 8m. | *Sm.* | D. | | Σ. | 8m. | *Sm.* | D. | Σ. | 8m. | *Sm.* | D. |
| 8¼ | 9 | 12 | 9 | | ° | ° | | ° | ″ | ″ | | ″ |
| 11 | 15 | not seen | 10½ | A B | 55·53.. | 53·0.. | ... | .. 53·7 | 2·37.. | 2·5.. | ... | .. 2¼ ± |
| 9¼ | 10 | 12 | 9¼ | A C | 167·38.. | 165·0.. | 169·25.. | 165·6 | 39·46.. | 40·0.. | 36·94.. | 36·2± |
| ... | 6 | 7½ | 6¼ | A D | ... | ..359·2.. | 360·35.. | 361·6 | .... | ..165·0.. | 880·54.. | 182·5± |

My positions and distances were only single measures with a very low power, for the sake of certain identification. Struve has not included the bright star D, which is, in fact, too distant to belong properly to the object he measured. How it should have happened that, though the group was so carefully examined with the Elchies Refractor, that fine instrument failed to show the star B, remains to be explained; for it certainly ought to be obvious enough in such a glass. It is an important fact, however, as showing how unsafe it is, because an object was not seen when it might have been supposed that it could not possibly have escaped observation, to conclude from this that it must therefore be variable in brightness.

With reference to the visibility of such very minute stars as are many of those which are adduced in proof of the optical power of the Elchies Refractor, it would, I think, be a great mistake to assume as certain, or even as very probable, that, because the existence of such minute specks, at a distance of one or two minutes, is not recorded, *therefore* they were not seen; and it would be a still greater mistake to assume that they *could not* have been seen, or even micrometrically measured, with the instruments in use, if the design of the observers had been to test the optical powers of their telescopes. For instance: as the group round P. xxi. 312, contains some of the smallest stars quoted as discovered by the Elchies Refractor, I turned my telescope upon it; and though the night was rather hazy and the star nearly four hours from the meridian, all the stars seen at Elchies were brought out without the slightest difficulty with power 94, except C, which, being pretty near the brightest star, required a higher power to draw it out.

The most valuable property in a telescope is undoubtedly a *fine sharp definition;* and wherever this exists, even in an ordinary degree, a very simple calculation will show of what magnitude a star must be to be visible with any given aperture. Thus an object-glass of 11 inches in diameter will show a star whose magnitude is about 12¼ of Struve's scale, or 18½ of Sir John Herschel's. Nor is the visibility of such a star, when *isolated*, greatly affected by the quality of the object-glass, unless very bad indeed; but it is far otherwise when a very

small star is within 2″ of one much brighter than itself; for then the visibility of the small star will chiefly depend on the fine definition of the brighter.

As there are now so many large telescopes, both refractors and reflectors, in existence and in process of manufacture, I hope soon to present to the Society a list of objects most suitable for severely testing their powers of definition, and well situated for observation in this latitude.

*Hopefield Observatory, Haddenham, near Thame,*
*Dec.* 10, 1862.

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## RECENT PUBLICATIONS.

*The Earth and its Mechanism; being an Account of the various Proofs of the Rotation of the Earth: with a Description of the Instruments used in the Experimental Demonstrations. To which is added, the Theory of Foucault's Pendulum and Gyroscope.* By H. Worms, Esq., F.R.A.S., F.G.S. London, 1862.

The work is intended as a complete collection of the various demonstrations of the Earth's Rotation, and the theorems connected therewith; the principal object being to promulgate a knowledge of the more recent discoveries and experiments relating to this branch of science. Thus particular attention is drawn to Arago's application of Wheatstone's revolving mirror for the measurement of the velocity of light. A minute account is given of the latest experiments on falling bodies, made by Prof. Reich in the mines at Freiberg, in addition to those of Benzenberg and Guglielmini; the phenomena exhibited by Foucault's pendulum and gyroscope are carefully explained, &c. The second part, intended for the perusal of the mathematical student, gives, from Hansen's *Theorie der Pendelbewegung* (Danzig, 1853), with some omissions and additions, an investigation of this dynamical problem of the motion of a pendulum as affected by the rotation of the Earth.

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*Annals of the Astronomical Observatory of Harvard College, Vol. III., Cambridge (U. S.),* 1862.

The volume has the second title, "Account of the Great Comet of 1858, by G. P. Bond, Director of the Observatory of Harvard College."

The following list of the titles of the several sections will give an idea of the contents of this splendid Monograph of Donati's Comet:—

I. Figure and Position of the Tail.—Comprising the original notes of observation upon the principal tail, between August 14th, 1858, and February 9th, 1859, quoted with full references to the original authorities, and accompanied by remarks indicating the principal points of interest. This section is illustrated by twenty-three engravings, on steel, of the appearance of the Comet to the naked eye, and by eight wood-cuts.

II. Observations upon the Secondary Tails.—The text is illustrated by three wood-cuts, and by the engravings and charts of the naked-eye views.

III. Reduction of Observations upon the Figure and Position of the Tail.—The results of the discussion are exhibited on a series of charts giving the normal outlines of the principal tail on twenty-eight dates, between September 16th and October 17th inclusive, and the axis of the principal secondary tail for seventeen dates.

IV. Probable Errors of Observations upon the Tail.

V. On the Deflexion of the Tail.—Describing a peculiarity in its upper regions during the first and part of the second week in October. Two plates of outlines and a wood-cut accompany the text.

VI. Columnar Structure of the Tail.—Relating to a remarkable feature faintly exhibited in the upper part of the tail.

VII. Reduction of Observations on the Secondary Tails.—The results of this discussion have been entered on the charts, with the outlines of the principal tail.

VIII. The Nucleus and Envelopes.—The original accounts descriptive of the telescopic appearance of the Comet are here quoted in the same form as in Section I. They are accompanied by twenty steel engravings.

IX. On the Outline of the Head of the Comet.—The discussion is illustrated by two plates, showing the normal outlines of the head of the Comet between Sept. 3d and Oct. 18th.

X. On the Branches and Central Darkness of the Tail.—Engravings of nine views of the Comet, 1860, III. are given in this Section.

XI. The Nucleus.—Containing a description of the nucleus, with particular reference to its size and changes of brightness.

XII. The Envelopes.—The various phenomena of the envelopes, their velocity of ascent, the dark and bright spots on their surface, and the question of their rotation or oscillation, are considered in this Section, which is illustrated by a lithographic plate of 138 telescopic views. The Section concludes with a notice of the envelope formation in the

Comet, 1860, III. and in the great Comet, 1861, II. accompanied by a steel engraving of the former.

XIII. The Outer Faint Veil.—Containing an account of this feature, with a reference to a similar peculiarity in the Comet, 1860, III.

XIV. On the Direction of the Initial Axis of the Tail.

XV. Conclusion.—This Section gives a general summary of the contents of the volume.

The naked-eye and telescopic views of the Comet, shown on a dark ground, are very beautiful specimens of steel engraving.

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*P. A. Hansen, Darlegung der theoretischen Berechnung der in den Mondtafeln angewandten Störungen; Erste Abhandlung.* Leipzig, 1862. (forms part of t. vii. of the *Abhandlungen der mathematisch-physischen Classe der Königlich. Sächsischen Gesellschaft der Wissenschaften*, pp. 93–497.)

In this elaborate memoir—the first part of the anxiously expected Theory of Prof. Hansen's Lunar Tables—the perturbations in longitude are completely calculated; but of the perturbations of the latitude and radius vector respectively, only the portion which the author designates as the principal one. The method employed is stated to be with a slight variation that explained in the *Fundamenta Nova Investigationis orbitæ veræ quam Luna perlustrat*, the demonstration of the fundamental formulæ is however given *de novo*. It is hardly necessary to mention that the numerical values of the coefficients are substituted in the first instance in the formulæ, and the multiplications and integrations carried out numerically. The author has compared his values of the perturbations of the longitude with those of Plana and Damoiseau, the differences being in some instances not inconsiderable; but he has not as yet made the comparison with those of Delaunay. At the conclusion of the memoir the author investigates the perturbations which depend on the figure of the Earth, and the mass and figure of the Moon.

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*Nouvelles Recherches sur la Figure des Atmosphères des Corps Célestes.* Par M. Edouard Roche. 4to, Paris, 1862. (Extrait des Mémoires de l'Académie de Montpellier, Section des Sciences, 1862.)

The present Memoir is a sequel to one published in the year 1854. The author, on the suggestion of M. Faye, has

since introduced into his calculations the hypothesis of a repulsion exerted by the Sun on the Cometary Atmosphere; the repulsion is assumed to act in the direction of the radius vector, and to vary as the inverse square of the distance from the Sun; but the intensity is supposed to depend on the matter operated upon, viz. that, while nothing for the nucleus, it becomes sensible or even considerable for the exceedingly rare atmosphere of the Comet.

The equation of the *couche de niveau* or level surface (which is of course a surface of revolution about the Sun's radius vector) is obtained in polar co-ordinates in a very simple form; for sufficiently small values of the parameter which determines the particular surface, the section of the surface is a sort of oval, elongated however on the side away from the Sun. Geometrically, however, there is a detached infinite branch of the section; and, when the parameter acquires a certain limiting value, the two branches unite together so as to form a curve with a double point on the side opposite the Sun; the *surface* has then a conical point. The physical conclusion is, that as soon as we come to this limiting form of the level surface, the atmosphere, instead of continuing to form finite envelopes surrounding the nucleus on all sides, will, so to speak, flow out through the conical point of the surface, and so give rise to a tail. Want of space prevents the giving a more complete account of this very interesting investigation.

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*Instrument to be disposed of.*

A Fraunhofer Equatoreal, with Circles read by two sets of Verniers to $4^s$ and $1'$, in good order. Inquiries to be addressed to the Assistant Secretary.

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ERRATUM.

Vol. XXIII., page 16, heading of Table C, *for* "in the year 1861," *read*, "the years 1854 to 1860."

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# MONTHLY NOTICES

OF THE

# ROYAL ASTRONOMICAL SOCIETY.

VOL. XXIII. *January* 9, 1863. No. 3.


Dr. LEE, President, in the Chair.

Major J. T. Walker, India;
H. M. E. Crofton, Esq., Inchinappa, Co. Wicklow;
Arthur J. Melhuish, Esq., 26 Haymarket; and
Richard Munday, Esq., R.N., Dockyard, Malta,

were balloted for and duly elected Fellows of the Society.

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*Observations on Saturn.* By Wm. Wray, Esq.

Telescope 7 inches clear aperture; 8½ feet focus.

1861, Dec. 17th, at $18^h\ 30^m$. On turning the telescope on *Saturn*, to my utmost surprise, with power 110, I instantly perceived the whole of the edge of the ring, not only where it crossed the dark shade on the body, but also extending on each side of the planet's margin. It was irregularly broken.

Dec. 23d, $17^h\ 20^m$. The edge of the ring again seen distinctly, and suspected to be thicker and somewhat nebulous about the region on either side, where it joined the planet's limb.

Dec. 26. Atmosphere very fine, and the image of *Saturn* exquisitely steady and well defined. The northern equatoreal belt was observed to consist of two narrow dark grey bands, connected by a broader region of a light brown colour: it thus had the appearance of being double. At $16^h\ 30^m$, the eastern arm of the ring was scarcely visible, whilst the western could not be overlooked, and was broken in two places. The

brightness of the eastern arm gradually increased; and at $18^h\ 30^m$ both were sensibly equal in light. At $19^h$ the eastern arm surpassed the western, and disappeared last in the twilight. A prolongation of very faint light stretched on either side from the dark shade on the ball, overlapping the fine line of light formed by the edge of the ring, to the extent of about one-third its length, and so as to give the impression that it was the dusky ring, very much thicker than the bright rings, and seen edgewise, projected on the sky. At $18^h\ 30^m$ I made the rough sketch, No. 1.

No. 1. 1861, Dec. 26, at $18^h\ 30^m$; two Satellites on the ring.

1862, Jan. 4th, $18^h\ 40^m$. Western arm much broken and brighter than the eastern, the faint overlapping light again seen.

Jan. 5, $13^h\ 30^m$. Edge of the ring well seen. Sketch,

No. 2. 1862, Jan. 5, at $14^h\ 0^m$; one Satellite on the ring.

No. 2, was made at $14^h$; the faint overlapping light was exceedingly distinct at this time. The western arm of the ring

much fainter and shorter than the eastern, which was proved by its becoming invisible on raising the power from 110 to 450, the eastern arm remaining visible under the latter power. At $16^h\ 40^m$ the arms were judged to be equal in length and brightness, and both visible with power 450. At $17^h\ 15^m$ and until $18^h\ 0^m$ the western arm was decidedly the brightest.

Jan. 11th, $14^h\ 0^m$. The edge of the ring again well seen, and the faint light before referred to unmistakeably visible.

Jan. 18th, $13^h\ 30^m$. The edge of the ring broken, and the arms equal in brightness and length; faint light again clearly perceived near the planet's margin.

Shortly after these observations the instrument was sent to Archdeacon Garbett, of Clayton, in Sussex; and on the 19th of May, at $10^h\ 30^m$, that gentleman and his sons clearly perceived the whole of the edge of the ring of *Saturn*.

The fine thread of light seemed to me always of a bluish-white tinge, very different in colour to the ball of the planet. The inner satellites were frequently perceived moving along the fine line of light; *Mimas* distinctly on two occasions.

*Clifton Villas, Highgate Hill,*
*Upper Holloway.*

---

*On the Observations of Saturn made at Pulkowa and Greenwich.* By the Astronomer Royal.

A paper has lately been received from M. Otto Struve, dated 1862, July 2, containing numerous details on the appearances presented by *Saturn* about the time of disappearance of his ring in May of that year.

It is not my intention here to transcribe the whole of M. Struve's observations. I shall only remark that M. Struve considers himself justified, by the views which he as well as M. Winnecke obtained with the Pulkowa Refractor, in assuming the existence of certain appendages (*appendices lumineux*) which are not the same as the ansæ of the ring.

No such idea suggested itself to the observers with the Greenwich Equatoreal.

I have requested Mr. Carpenter to draw up an account of his observations, and I ask leave to place them before the Society in juxtaposition with extracts from the remarks of M. Otto Struve. On the whole the accordance is good.

It will be remembered that "left" in Mr. Carpenter's language corresponds to "preceding" in M. Otto Struve's.

J. C.

1862. May 5.

Right ansa longer by $\frac{1}{10}$ than the left.

May 13.

Ring of a dirty copper colour.

(A drawing was made.)

STRUVE.

1862. May 15.

The line of ansæ perfectly well visible. On the north side it is more glittering, and limited by a sharp edge. On the south side, on the contrary, it appears as if clouds of a less intense light were lying on the ansæ.

On the body of the planet the obscure ring is visible, but I cannot see traces of the above-mentioned clouds.

*Measures of Ansæ.*

Preceding, 11″·07;
following, 10″·35.

May 16.

Preceding ansa without doubt longer than following ansa in the proportion of 5 to 4.

May 17.

The ring beyond the planet at times just visible on the left of the disk, but on the right only a small faint spot could be seen in the plane of the ring, about $\frac{1}{3}$ the diameter of the disk from the planet's limb. I should have suspected this was a satellite but for its elongated shape.

Sky very hazy.

May 17, 15$^h$.

The preceding ansa estimated to extend 11″·4, or at most 13″·3 beyond the planet.

The light of the preceding ansa is of the colour of rose copper, and considerably stronger on the side touching the planet.

(Computed time for disappearance of ring, May 17$^d$ 19$^h$.)

May 18.

I see the ansæ distinctly; they offer the same appearance as yesterday.

May 19.

*Saturn* very well seen. The ring distinctly visible on the left of the disk; and fairly, but not so distinctly visible on the right. Where it crosses the disk the under edge is much sharper and better defined than the upper edge.

(A drawing was made.)

May 19.

I see distinctly traces of the ri[illegible] especially on the preceding side.

The luminous appendages exte[illegible] on the preceding side to 0·6, and [illegible] the following side to 0·3 of [illegible] diameter of the planet.

Their colour differs much [illegible] the ordinary colour of the [illegible] They are not yellow, but m[illegible] a livid colour, brown, and blu[illegible]

May 20.

*Saturn* very well seen; the ring distinctly visible, appearing brighter than it did last night.

(The drawing made last night may be considered as a fair representation of the planet's present appearance.)

May 20.

The aspect of the luminous appendages has not varied since last night, with this difference only — that I estimated the length of the preceding side as 0·65, and the following as 0·5 of the planet's diameter.

May 21.

Images good.

Estimated extent of luminous appendages: — Preceding side 0·6, following side 0·4, of the planet's diameter; also the intensity of the light appears much more feeble on the following side. The size of these appendages increased in the neighbourhood of the planet, giving them the form of sharp wedges.

May 22.

Images less favourable than yesterday. Extent of luminous appendages on preceding side 0·6, on following side 0·5 of the planet's diameter.

May 25.

The ring still just visible.

June 1.

The ring still visible during moments of good definition.

June 3.

*Saturn* well seen. The ring very plainly visible. During moments of very good definition I fancy I can see the flat surface of the ring very faintly illuminated.

June 3.

Image very bad, yet the luminous appendages are still distinctly visible. It appears that the length of the following ansa is a little the greater, but this is not certain.

*December* 22, 1862.

---

Mr. Joynson communicated to the Society a series of thirty-six drawings of *Mars*, taken at Waterloo, near Liverpool, at. 53° 28′ 24″ N., Long. 3° 1′ 44″ W., accompanied with the following explanation:—

The diagrams are selected from a considerable number of drawings of the planet *Mars*, about the time of his opposition, and extend from the 25th of Sept. to the 10th of Nov., 1862. They were taken with a lens of $3\frac{1}{2}$ inches aperture, and a power of 370, both lens and eye-piece being made by Messrs. J. Cooke and Sons, of York. They are arranged so as to show the appearance of the planet during the whole time of its rotation, and a few are repeated so as to show that the aspect of the planet was not changed during the time the observations were continued.

The results of the observations appear to be,—

1st. That the band is continuous round the planet, with the exception of the place where the pale yellow stripe crosses it, as marked in the diagram of 5 October.

2nd. That the snow at the south pole is not exactly on the axis of rotation.

3rd. That the time of rotation is $24^h\ 37^m\ 49^s$.

No opinion is offered as to the permanency or otherwise of the band, but it is found that the disk continues (Nov. 1862) to show the appearances that it did at first, so that there is no difficulty in knowing what part has passed and what has to be seen later in the night.

The general colour of the planet (beside the band) was yellow, save a part in the northern hemisphere, seen between the 12th and 24th October, which was reddish. Sometimes the band had a dead greenish cast, and sometimes it was of a purplish line, but in the main it was very dark. On the 26th October the opening from it appeared to extend very nearly to the snow at the south pole, and then to form a darkish semi-circle about it.

It may be remarked, that in general the northern hemisphere to the northern edge of the band has been the best to define, whereas the southern hemisphere has mostly been rather indistinct, and the yellow colour less perceptible than in the northern. The small circle on each diagram marks the position of the snow.

The planet has now become gibbous, and is both smaller and worse to define with the same eye-piece than when the observations were commenced.

The telescope is equatoreally mounted, and was driven by clockwork during the observations.

The eye-piece was the ordinary Astronomical Inverting kind.

*Liverpool, 18th Nov.* 1862.

*Note on* U *Geminorum.* By J. Baxendell, Esq.

On the night of 26th Dec. 1862, I was surprised to find U *Geminorum* shining as a star of the $10\frac{1}{2}$ magnitude, although, according to calculation, it ought at that time to have been nearly in the middle of its phase of minimum brightness, and therefore below the 14th magnitude; but on the 29th, and again on the 30th, it was invisible in a sky which permitted stars of the $12\frac{1}{2}$ magnitude in the immediate neighbourhood to be seen. The maximum must therefore have occurred previous to the 26th; and fortunately, owing to the kindness of Mr. Knott, I am enabled also to state that it was subsequent to the 20th. In a letter from this careful observer, dated January 6, 1863, he says, "I was not fortunate enough to obtain any observations of the recent unexpected maximum of that *most eccentric* variable, U *Geminorum*. I find from my journal, however, that I *looked for it* on December 20th, *but to no purpose*, though Mr. Pogson's '*g*' and '*h*' were well in view. The night was but indifferent, but I think we may safely assume the variable to have been below 12·3 or 12·5 mag." Mr. Knott also remarks that his observation, combined with mine, seems to show that either the changes were *very rapid*, or that the maximum was *rather a faint one*.

The occurrence of this maximum is, I believe, the greatest deviation from the usual course of the changes of U *Geminorum* that has yet been observed; and it shows very strikingly the importance of keeping a constant watch over variables of this class. It also shows the necessity of a material modification of the elements derived by Mr. Pogson from the early observations of this Star.

With reference to Mr. Knott's remark, "that either the changes were *very rapid*, or that the maximum was *rather a faint one*," it may be observed that a maximum of equally short duration occurred in November, 1858. On that occasion the variable attained the 9·3 magnitude, and yet the whole time of visibility with ordinary telescopes did not exceed *nine* days.

*Manchester, January* 8, 1863.

---

*On the Elchies Equatoreal.* By G. Knott, Esq.

Mr. Knott, in a letter dated Woodcroft, Cuckfield, Jan. 8, 1863, after referring to the quadruple star 222 P. I. *Arietis* (one of the objects examined by the Astronomer Royal for Scotland with the Elchies Refractor), writes as follows:—

"It has occurred to me, however, that it may not be uninteresting to the Members to learn that all four components of that group are very readily (I had almost said easily) visible in my 7½-inch Alvan Clark refractor, and that I should be inclined to attribute (as has been remarked by Mr. Dawes) any difficulty in catching up the small star 'B' less to its faintness than to its proximity to the brighter star 'A.' We have an illustration of this same principle in the case of the celebrated 'sixth star' in the nebula of *Orion*, for securing which sharp definition is far more necessary than great light in a telescope.

"From observations on Dec. 10, 12, 15, 20, I estimate the magnitudes of the members of the group (222 P. I.),

A 9·4 : B 11·3 : C 10·1 : D 6;

or reducing to Prof. Struve's scale (which is also that of Mr. Dawes),

A 8·5 : B 9·9 : C 9·1 : D 6

"A comparison of these with Mr. Dawes' values seems to indicate that I have rated them rather too high. A and C, however, accord well with Σ's estimates in the *Mens. Microm.*

"A rough set of wire-micrometer measures, on Dec. 12, yielded the following results, which are, of course, approximate merely:—

| | | | | | |
|---|---|---|---|---|---|
| AB | Angle of Position | 50° ± | Distance | 2½″ ± | Estimated. |
| AC | — | 166·4 | — | 37·3 | |
| AD | — | 360·8 | — | 133·6 | |

"By differentiating D with *β Arietis*, I at once recognised it as the star observed by Piazzi (*Hora* i. No. 222), and was not long in coming to the conclusion that, somehow or other, the magnitudes of A and D in the *Bedford Catalogue* had been interchanged. This little oversight being rectified, the magnitude values of the various meridian and extra-meridian observers are found to be in admirable accordance, and the invariability of the group settled apparently beyond a doubt."

---

*Observations of Comet II.* 1862, *taken at the Observatory of J. Gurney Barclay, Esq., at Leyton, Essex, and communicated by him.* By Hermann Romberg.

The following observations of Comet II. 1862 were taken with the ring-micrometer on the large Refractor, and are corrected for refraction and parallax:—

| 1862. | G.M.T. h m s | Comet's R.A. h m s | Comet's Decl. ° ′ ″ | |
|---|---|---|---|---|
| July 31 | 10 53 28·8 | 5 54 13·92 | +73 2 36·4 | *a* |
| Aug. 1 | 13 1 31·2 | 5 58 56·46 | 73 39 19·1 | *b* |
| 3 | 12 44 8·5 | 6 9 25·21 | 74 52 0·3 | *c* |
| 5 | 9 25 37·0 | 6 22 17·11 | 76 4 58·8 | Meridian. |
| 7 | 9 38 38·5 | 6 41 30·61 | 77 31 38·7 | *d* |
| 14 | 11 15 55·6 | 9 46 35·95 | 82 0 29·3 | *e* |
| 15 | 12 3 3·9 | 10 38 50·71 | 81 55 3·0 | *f g* |
| 18 | 8 55 32·3 | 12 54 24·60 | 79 8 42·1 | *h* |
| ,, | 9 4 17·9 | 12 54 37·06 | 79 8 7·7 | *i* |
| 22 | 9 29 10·3 | 14 35 48·21 | 68 58 10·7 | *k* |
| ,, | 12 28 53·4 | 14 37 43·63 | 68 32 13·3 | *l* |
| 23 | 10 56 23·3 | 14 50 38·49 | 65 7 29·6 | *m* |
| 24 | 12 30 54·0 | 15 2 44·51 | 60 46 22·6 | *n* |
| ,, | 13 21 2·8 | 15 3 6·47 | 60 37 19·0 | *o* |
| ,, | 14 4 2·4 | 15 3 23·50 | 60 29 35·3 | *o* |
| 25 | 10 57 50·8 | 15 11 32·73 | 56 32 40·7 | *p* |
| ,, | 11 30 52·4 | 15 11 44·36 | 56 26 4·9 | *q* |
| 27 | 12 16 19·9 | 15 26 37·13 | 46 0 31·0 | *r* |
| 28 | 11 55 26·4 | 15 32 33·15 | +40 13 14·4 | *s* |

*Mean Places of the Stars of Comparison for* 1862·0.

| | R.A. h m s | Decl. ° ′ ″ | |
|---|---|---|---|
| *a* | 6 1 15·42 | +72 59 17·0 | Arg. Zon. and Radcl. Cat. |
| *b* | 6 0 11·71 | 73 45 11·0 | A. Z. |
| *c* | 6 4 39·03 | 74 53 38·3 | ,, |
| *d* | 6 41 33·51 | 77 24 22·7 | ,, |
| *e* | 9 17 8·06 | 81 55 53·5 | Radcl. Cat. |
| *f* | 10 26 29·11 | 81 51 16·1 | Redhill Cat. |
| *g* | 10 28 8·04 | 81 57 11·1 | ,, |
| *h* | 12 51 46·93 | 79 14 51·3 | A. Z. |
| *i* | 12 56 29·83 | 79 10 56·9 | ,, |
| *k* | 14 35 27·52 | 69 2 45·5 | ,, |
| *l* | 14 36 25·48 | 68 37 1·8 | ,, |
| *m* | 14 51 50·93 | 65 12 24·4 | ,, |
| *n* | 14 58 13·51 | 60 44 51·1 | Radcl. Cat. |
| *o* | 15 0 13·46 | 60 33 51·7 | ,, |
| *p* | 15 10 2·56 | 56 38 2·6 | ,, |
| *q* | 15 12 20·76 | 56 31 10·2 | A. Z. |
| *r* | 15 27 18·48 | 46 6 6·2 | ,, |
| *s* | 15 31 2·81 | +40 17 15·3 | Radcl. Cat. |

I watched with great interest the very remarkable pheno-

mena presented by the nucleus, but was unable to take measures of the luminous streamer on account of the wire-micrometer being unfortunately under repair.

Mr. G. Barclay's observatory is situated at Leyton, in Essex, in longitude $0^h\,0^m\,0^s{\cdot}8$ W., and latitude $51^\circ\,34'\,34''$ N. This determination was obtained by Mr. John Worden, by connecting it with a point in the Trigonometrical Survey close at hand. The instruments are a fine Refractor, by Cooke and Sons, of York, of 10 inches aperture and 12 feet focal length. The mounting is upon the well-known German principle, and unites beauty of workmanship with great firmness and solidity. To the Refractor is attached a spider-line and double-image micrometer, the former being chiefly intended for measures of double stars. In order to facilitate these measures, an excellent driving-clock by the same maker was added in the past summer, which has given perfect satisfaction. It is proposed to measure, as far as practicable, the stars in W. Struve's last Pulkova Catalogue, Bessel's selected list, the known revolving double stars, and a number observed by Admiral Smyth in the Bedford Cycle. Observations of the fainter Small Planets it is hoped to procure, with a new wire-micrometer provided with illuminated wires in a dark field.

The Observatory contains also a Meridian-Circle by Troughton and Sims, the telescope having an aperture of 4 inches and focal length of 4 feet; the circles are 3 feet in diameter, divided to every five minutes, and read by four microscopes. The inclination of the instrument is determined by a level, and the errors of azimuth and collimation by observing northern stars and reversing. I hope to make a good use of this instrument, not only for the common determinations of time, longitude, and latitude, but for observations of Planets, and later for ascertaining the positions of Comparison-Stars.

The Sidereal Clock is by Simmons, and has a very satisfactory rate. In September and October I obtained some observations of *Mars* in opposition, using also the method recommended by the Astronomer Royal. The weather, however, was generally unfavourable. Since that time I have carefully examined the screw of the wire-micrometer, and have now measures of about 80 double stars, in part of which the double-image micrometer was employed. It is right to state that the mounting of the instruments was superintended by Mr. John Worden.

*J. Gurney Barclay's Observatory,*
*Leyton, January* 4, 1863.

## *Observations and Elements of Comet II.*, 1862.
By J. Tebbutt, Esq.

Mr. Tebbutt, in a letter dated Windsor, New South Wales, October 20th, 1862, writes:—

"I herewith enclose my latest observations of a large Comet which suddenly made its appearance here on the evening of the 1st September. The observations were made with a telescope of 3¼ inches clear aperture, and 4 feet focal length, provided with a ring micrometer diameter 20′ 50″. They are not so accurate as I could wish, owing to the faint and diffused light of the comet during the present month; they will, however, prove useful in the event of the comet not being more accurately observed elsewhere. The Rev. W. Scott resigned some time since his appointment as Director of the Sydney Observatory, but some observations have been made of the Comet by his assistant. I believe, however, they are not in a state to be forwarded to Europe by this opportunity. The physical changes of the Comet during the early part of September were very remarkable, for a brief notice of which I beg to refer you to a paper read by me before the Philosophical Society of this colony on the 8th instant. The paper is published in the *Sydney Morning Herald* of the 9th instant, a copy of which I forward with this letter. I have deduced the following elements from observations extending from the 1st September to the 15th instant.

Perihelion passage, 1862, August 23$^{d}$·1340 Greenwich Mean Time.

| | | |
|---|---|---|
| Perihelion distance | 0·96290 | |
| Distance of perihelion from ascending node in the direction of motion | 152° 49′ 48″ | |
| Longitude of ascending node | 137 13 36 | Mean Eq. of 1 Jan. 1862 |
| Inclination of orbit | 66 9 36 | |

Motion retrograde.

The most remarkable feature of the Comet's orbit is its near approach to the Earth's path at the descending node; according to my calculations the distance between the two orbits at that point is only half a million of miles. This Comet cannot be identical with that discovered by M. Tempel at Marseilles on the 2d July.

| 1862. | Greenwich Mean Time. h m s | Star of Comparison. | Comet—Star. R.A. m s | N.P.D. ′ ″ |
|---|---|---|---|---|
| Sept. 19 | 21 49 48 | B.A.C. 5538 | − 8 34·2 | − 3 4 |
| | 22 13 7 | ,, ,, | − 8 33·4 | − 1 57 |
| | 22 37 29 | ,, ,, | − 8 31·4 | − 0 55 |

| 1862. | Greenwich Mean Time. h m s | Star of Comparison. | Comet — Star. R.A. m s | N.P.D. ′ ″ |
|---|---|---|---|---|
| Sept. 25 | 23 27 28 | B.A.C. 5593 | −11 16·1 | −11 43 |
| 26 | 0 7 2 | ,, ,, | −11 12·6 | −11 20 |
| | 22 5 51 | ,, 5583 | − 9 30·3 | + 9 6 |
| | ,, | ,, 5584 | − 9 38·3 | + 9 26 |
| | 22 21 15 | ,, 5583 | − 9 30·4 | + 9 18 |
| | ,, | ,, 5584 | − 9 38·6 | + 9 29 |
| Oct. 3 | 21 59 27 | Brisbane 5754 | + 5 1·3 | |
| | ,, | ,, 5799 | − 1 37·3 | |
| | 22 6 10 | ,, ,, | − 1 36·5 | − 3 16 |
| | 22 18 17 | ,, 5754 | + 5 3·7 | + 5 58 |
| 9 | 21 47 59 | *a* | + 0 26·6 | +12 22 |
| | ,, | *b* | − 2 11·6 | +15 4 |
| | 21 54 41 | *a* | + 0 26·5 | +12 14 |
| | ,, | *b* | − 2 11·6 | +15 3 |
| | 22 7 33 | *a* | + 0 27·1 | +12 21 |
| | ,, | *b* | − 2 11·4 | +15 10 |
| | 22 15 3 | *a* | + 0 26·1 | +12 47 |
| | 22 19 30 | *a* | + 0 25·6 | +12 45 |
| | 22 23 46 | *a* | + 0 26·6 | +12 36 |
| | 22 29 45 | *a* | + 0 25·8 | +12 38 |
| | 22 34 37 | *a* | + 0 24·6 | +12 42 |
| | | | *a* − B.A.C. 5472 | |
| | | | +17 36·7 | + 8 3 |
| | | | *b* − B.A.C. 5472 | |
| | | | +20 14·1 | + 5 11 |
| 12 | 21 40 32 | Lacaille 6907 | + 7 8·2 | |
| | ,, | B.A.C. 5558 | + 6 32·3 | |
| | 21 52 10 | Lacaille 6907 | + 7 10·7 | +11 40 |
| | ,, | B.A.C. 5558 | + 6 35·2 | +11 7 |
| 14 | 21 19 20 | ,, 5561 | + 8 2·6 | − 2 7 |
| | ,, | *c* | − 0 47·1 | +16 25 |
| | 21 32 38 | B.A.C. 5561 | + 8 4·0 | − 2 31 |
| | 21 45 2 | ,, ,, | + 8 5·3 | |
| | 21 56 40 | ,, ,, | + 8 2·8 | − 1 49 |
| | ,, | *c* | − 0 48·6 | +16 42 |
| | 22 9 37 | B.A.C. 5561 | + 8 5·8 | − 1 49 |
| | ,, | *c* | − 0 44·1 | +16 42 |
| | | | *c* − B.A.C. 5561 | |
| | | | + 8 50·4 | −18 31 |
| | | | *c* − Brisbane 5850 | |
| | | | − 1 23·0 | +11 1 |

| | | |
|---|---|---|
| Long. of place of observation | $10^h\ 3^m\ 42^s$ | East of Greenwich |
| Lat. of place of observation | $33°\ 36'\ 30''$ | South |

## *Remarks.*

Where the difference of N.P.D. is not given it is to be understood that one of the objects crossed the ring near its centre. The stars *a*, *b*, are of the 7 mag., and *c* of the 7·8 mag. B.A.C. 5558 is double; the *following* star was employed in the comparisons of the 13th October. The following are the mean places of B.A.C. 5538 and 5583 from observations made at the Sydney Observatory.

B.A.C. 5538, January 1, 1859, R.A. $16^h\ 27^m\ 6^s{\cdot}44$, N.P.D. $124°\ 57'\ 39''{\cdot}4$ from six observations in 1859.

B.A.C. 5583, January 1, 1860, R.A. $16^h\ 34^m\ 3^s{\cdot}41$, N.P.D. $130°\ 50'\ 49''{\cdot}6$ from one observation in 1860.

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## *Places of Comet II.* 1862, *observed at Armagh.*

By N. M'N. Edmondson, Assistant at the Observatory.

(*Communicated by Dr. Robinson.*)

| 1862. | Greenwich M.T. h m s | R.A. h m s | s | N.P.D. ° ′ ″ | ″ |
|---|---|---|---|---|---|
| Aug. 27 | 11 6 36·49 | 15 26 18·27 | $+\varpi\times$ 0·05596 | 43 41 54·28 | $-\varpi\times$ 0·52008 |
| 28 | 9 16 17·63 | 15 31 41·87 | 0·04292 | 48 52 52·70 | 0·39972 |
| 29 | 9 4 21·21 | 15 36 46·30 | 0·04231 | 54 41 45·17 | 0·46049 |
| 31 | 9 32 36·89 | 15 45 8·31 | 0·03666 | 66 38 39·70 | 0·63061 |
| Sept. 1 | 8 52 44·77 | 15 48 33·28 | 0·03132 | 72 14 58·45 | 0·66010 |
| 7 | 8 44 41·06 | 16 3 10·20 | 0·03038 | 99 50 47·09 | 0·86420 |
| 8 | 8 36 46·11 | 16 4 52·93 | 0·03009 | 103 7 5·87 | 0·87828 |
| 9 | 8 32 25·68 | 16 6 59·92 | $+\varpi\times$ 0·03019 | 105 57 15·46 | $-\varpi\times$ 0·88794 |

| | Comparison Stars. | Comparisons. | Assumed Places. |
|---|---|---|---|
| Aug. 27 | Lalande 28208 | 5 | Lalande. |
| 28 | 52 Boötis | 5 | Armagh Catalogue. |
| 29 | P. xv. 148 | 6 | R.A. from P., N.P.D. from Armagh. |
| 31 | Lalande 28875 | 4 | Lalande. |
| Sept. 1 | P. xv. 203 | 6 | R.A. from Armagh, N.P.D. from P. |
| 7 | 15 Scorpii | 5 | Ditto ditto B.A.C. |
| 8 | Lalande 29671 | 5 | Lalande. |
| 9 | Argelander Zone 297, No. 76* | 6 | Argelander. |

* I am indebted to Mr. Ridings, of Markree, for the name and places of this star. Its identity with the comparison star seems doubtful. The comet preceded the star in R.A. $4^s{\cdot}25$, and was north of it $5'\ 42''{\cdot}08$.

## *Results of the Meridional Observations of Small Planets, and an Occultation of a Star by the Moon; observed at the Royal Observatory, Greenwich, in the month of December, 1862.*

(*Communicated by the Astronomer Royal.*)

### *Themis* (24).

| Mean Solar Time of Observation. | | R.A. from Observation. | N.P.D. from Observation. |
|---|---|---|---|
| | h m s | h m s | ° ′ ″ |
| 1862, Dec. 1 | 10 27 32·5 | 3 9 36·10 | 71 52 6·81 |
| 13 | 9 32 45·4 | 3 1 58·70 | 72 21 20·07 |

### *Urania* (30).

| Mean Solar Time of Observation. | | R.A. from Observation. | N.P.D. from Observation. |
|---|---|---|---|
| | h m s | h m s | ° ′ ″ |
| 1862, Dec. 1 | 13 13 7·1 | 5 55 37·90 | 63 44 12·28 |
| 10 | 12 28 9·1 | 5 46 1·55 | 63 51 29·48 |
| 11 | 12 23 5·2 | 5 44 53·37 | 63 52 41·11 |
| 13 | 12 12 56·2 | 5 42 35·81 | 63 55 9·49 |
| 23 | 11 22 17·2 | 5 31 14·04 | 64 12 10·92 |
| 29 | 10 52 29·7 | 5 25 0·97 | 64 24 51·72 |

All the observations of N.P.D. have been corrected for Refraction and Parallax.

### *Occultation of α Cancri by the Moon.*

Observed on Dec. 10, by Mr. Criswick. The disappearance took place at the Moon's Bright Limb at $15^h\,54^m\,54^s{\cdot}8$, and the reappearance at the Dark Limb at $17^h\,4^m\,46^s{\cdot}9$ M.S.T.

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## *Observations of Asia* (67), *taken with the Equatoreal of the Liverpool Observatory.* By J. Hartnup, Esq.

| 1862. | G.M.T | R.A. (67) | Log. $\frac{p}{P}$ | N.P.D. (67) | Log. $\frac{q}{P}$ | Star of Comp. B.A.C. |
|---|---|---|---|---|---|---|
| | h m s | h m s | | ° ′ ″ | | |
| Dec. 10 | 9 50 43·4 | 3 34 14·84 | −7·829 | 77 6 15·2 | −9·8114 | 1241 |
| 10 | 10 20 37·7 | 3 34 13·76 | −7·154 | 77 6 19·4 | −9·8104 | ,, |
| 10 | 10 50 32·0 | 3 34 12·51 | +7·592 | 77 6 23·2 | −9·8105 | ,, |
| 11 | 10 23 55·2 | 3 33 28·76 | .. | 77 9 15·0 | −9·8108 | ,, |
| 11 | 10 53 49·7 | 3 33 27·42 | +7·727 | 77 9 17·5 | −9·8114 | ,, |
| 17 | 9 56 20·9 | 3 29 30·02 | .. | 77 24 1·3 | −9·8130 | 1087 |
| 17 | 10 11 18·4 | 3 29 29·39 | +7·426 | 77 24 2·3 | −9·8130 | ,, |
| 17 | 10 26 16·2 | 3 29 29·02 | +7·726 | 77 24 4·1 | −9·8136 | ,, |

The observations are corrected for refraction. The corrections to be applied for parallax in time and arc are represented by $p$ and $q$. P is the equatoreal horizontal parallax.

The following are the assumed mean places of the stars of comparison for 1862, January 0:—

| | R.A. | N.P.D. | Authority. |
|---|---|---|---|
| | h m s | ° ′ ″ | |
| B.A.C. 1241 | 3 53 2·34 | 77 54 9·45 | Greenwich Observations. |
| ,, 1087 | 3 23 15·49 | 77 32 20·39 | ,, ,, |

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Mr. Warren De La Rue exhibited at the January Meeting a photograph of the Moon, taken near the dichotomy, enlarged so as to correspond in size with the map published by Beer and Mädler, and called the attention of the Fellows to the great progress which has been already made in Photographic Selenography.

Mr. De La Rue stated that, when he first commenced to map the lunar surface, the only way of procedure possible in the then state of the photographic art was, after the original negative had been taken, to place it under the microscope, and make, with the aid of the camera lucida, an enlarged copy of such portions of it as might be required by hand. Latterly, however, a more direct method has been discovered, by means of which, as Mr. De La Rue pointed out to the Meeting, the magnificent photograph enlarged thirty-eight times from the original negative had been produced. In the first instance a positive on glass was obtained, nine inches in diameter, from the original negative of one inch in diameter; and at the second operation a series of negatives were procured on a scale of thirty-eight inches for the Moon's diameter.

Mr. De La Rue, while bearing full testimony to the valuable labours of MM. Beer and Mädler, pointed out that their map did not give a true representation of the lunar surface as a chart, it only *mapped* it, while the photograph does both; and, although the latter might not be quite so sharp in its outlines as might be wished, still one must be contented to lose something in exchange for the great magnification of the negative. The combination of favourable circumstances necessary for the production of a perfect photographic picture was then alluded to. Atmosphere, collodion, instrument, driving-clock, all must be perfect; and the very rare occasions on which this combination occurs may be judged of from the fact that of four hundred negatives taken by Mr. De La Rue during the last five years, about twenty only are capable of producing a perfectly sharp photographic record; the tremulous motion in the

image from atmospheric defects being the *main* cause of the difficulty.

Turning to another allied subject, the photographs of the Solar Eclipse, Mr. De La Rue referred to certain discrepancies (to which he had alluded in his Bakerian Lecture on the Total Solar Eclipse of 1860, read before the Royal Society), between the photographs taken by Father Secchi and his own, and stated that, on a recent visit to the Roman Observatory, he remarked a photograph differing considerably from those which have been distributed in this country, by the kindness of Señor Aguilar, who had accompanied Father Secchi. Father Secchi's copy bore a very much greater resemblance to Mr. De La Rue's than these latter; and, upon inquiry, he found that after the first few positives had been taken from the original negatives, they had been subjected to a process technically called "strengthening," which, in this instance, had completely blotted out all the minute detail at first recorded.

While Mr. De La Rue was in Rome, Father Secchi's copy of the first place of totality was enlarged, and he brought back with him to England a negative corresponding in size with those taken with the Kew Heliograph by himself; and he has found, on tracing both and comparing the tracings, that the similarity is complete, with the exception that two luminous prominences are seen in Father Secchi's photograph which were not visible from Mr. De La Rue's station; that is, the only discrepancies between the two photographs taken at the two stations could be explained by the greater covering of the Sun in the one or other direction by the parallax of the Moon, dependent on the observers' positions, with respect to the central line of the eclipse. J. N. L.

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*Memorie Astronomiche.* Del Prof. Donati. (Published in the Annals of the Museum at Florence, 1862.)

(*Abstract by S. M. Drach, Esq.*)

The first memoir, dated August 1860, is on the Striæ of Stellar Spectra. After quoting Fraunhofer, in Schumacher's *Astron. Abhand.*, Part ii., 1823, and in Gilbert's *Annalen der Physik* (vol. lxxiv., 1823), on the spectra of stellar and planetary light rays, the author states that he used a large burning lens kept in the Museum since 1690, and whereon Targioni, Averani, and Sir H. Davy had experimented. This lens has a diameter of 0·41 metres, and a focal distance of 1·58 metres (15 and 62½ inches). The lens was mounted parallactically on a movable stand: a piece with a fine slit was placed a short distance within the focus of the lens, through which the stellar rays passed. Within this lens-tube

is a cylindrical lens with its very short focus, coinciding with that of the great lens. The stellar ray then falls on a prism fixed on a graduated circle, to which is attached a small achromatic telescope (object-glass, aperture 0·024; focal distance 0·17 metre; eye-piece magnifies 12 times). There is also at the end of the great lens-tube an achromatic lens equal to the object-glass of the telescope. Thus the stellar rays are passed through the cylinder-lens, the tube-achromatic, the prism, and the telescope-lenses before reaching the observer's eye. In the focus of the achromatic telescope are two metallic bars, one fixed, the other movable by a micrometer-screw. A cylinder-lens was preferred to a simple slit, for the purpose of getting the two lateral segments of the fasciculus of rays, which are lost in the ordinary diaphragm. But as by changing the position of the star observed, as respects the direction of the optical axis of the collecting lens, we change the position of the focal straight line produced by the cylindrical lens, making it impossible to keep the said straight line always in the same position as regards the prism, the author placed a metallic lamina at a distance from the cylinder-lens, equal to the focal distance of the latter. In the said lamina is a thin longitudinal slit, through which one sees the light-line formed in the focus of the cylinder-lens; thus certifying, when that line is visible, that it is always in the same position relative to the prism.

The author then proceeds as follows:—

I observed by day the solar spectrum, placing over the great lens a cloth, so fixed that it transmitted only the requisite quantity of light, and fixed the prism *p* to correspond to one or the other of the solar striæ; then fixing the telescope, I turned the movable bar, till one of its limbs touched the said stria at its minimum, and I read the corresponding division of the micrometer-screw. Leaving everything in this state, I turned the great lens in the evening to the star I wished to observe, and by the micrometer-screw immediately obtained the position of the stellar striæ, referred to the solar one observed in the morning. Besides the position of the stellar striæ, I have tried to determine the extremes of the spectra themselves, for which see Table.* I denote the striæ of the stellar spectra by the Greek letters, $\alpha$, $\beta$, $\gamma$, proceeding from the least refracted end of the spectrum. The unlettered striæ have not been measured, but simply estimated, as being very difficult. I have grouped separately the separate-coloured stars, giving in each group the first place to the most conspicuous striæ, and so in order; classifying them from Humboldt's *Cosmos*, and Schmidt, in *Astr. Nachr.* The Table indicates that the stellar striæ have a certain relation to the star's colour. Thus the white stars seem to have a family likeness; and so the yellow, orange, and red ones. There is

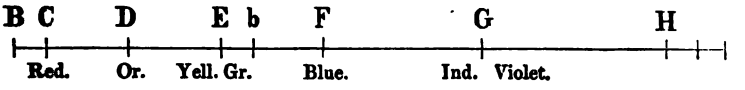
* See the figure, p. 103, roughly reduced from Prof. Donati's Memoir, and the numerical values, p. 104.— Ed.

likewise a great difference in the lengths. The three yellow stars have nearly the same maximum refraction end, but different minimum refraction ends; the reverse with the red stars. True, the measures of these ends (and indeed of the maximum refraction) are very uncertain, depending on the glass of the lenses and prism, and on the observer's eye. (Professor Amici has constructed a prism of very great dispersive power, without altering the axis of vision. It is composed of three prisms; the two outer ones of crown-glass, the inner one of boro-silicate of lead. Looking through this prism at a slit or luminous line, light is decomposed, with the same striæ as through a simple prism of flint-glass.) My prism was of flint-glass; refraction angle 60° 52′ 39″; angle of refraction of stria D of the solar spectrum (*i. e.* the angle which the refracted ray corresponding to D makes with the incident ray) is 49° 55′ 05″. The intermediate angles of the solar spectrum were found

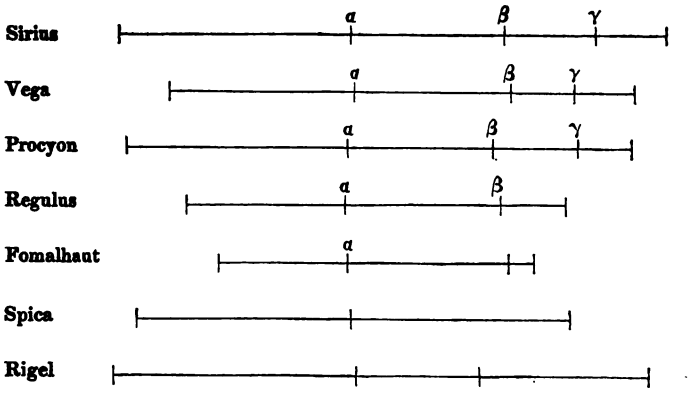
| | | |
|---|---|---|
| BC = 10′ 57″ | Eb = 7′ 45″ | FG = 72′ 9″ |
| CD = 30 35 | bF = 29 16 | GH = 65 56 |
| DE = 40 41 | | |

All these angles I have measured by the theodolite as accurately as possible. The rim of the micrometer-screw = 11′ 5″; each of the 100 divisions of the head = 6″·65. Its movable bar was broad enough to be seen without illuminating the telescope; and I always placed the same limb in contact with the measured striæ. I observed when the star was close to the meridian, giving me more definite striæ; but we must not conclude that the striæ change with the altitude of the star; the horizontal scintillations naturally disturb the precision of the spectrum. Whilst observing, I tried to be in the dark as much as possible; ordering another to read the micrometers; for when the eye is fatigued, even by the feeble light of a lantern, it could not perceive the feeblest striæ of the stars. In cloudy or moonlight nights, the observations were uncertain and sometimes absolutely impossible. Although the great lens was not achromatic, yet, looking through the telescope at the slit illumined by the rays collected by the cylinder-lens, it appeared perfectly white and without perceptible coloured edges.

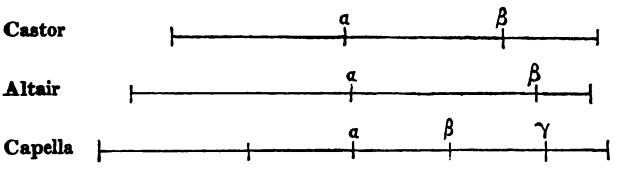
The following measures are the means of many observations thus obtained. Each star has its stria $\alpha$ referred to the solar F. Thus, for *Sirius*, $\alpha = F\odot - 15''$ means that *Sirius* $\alpha$ is refracted 15″ less than Sun F; and for *Vega*, $\alpha = F\odot + 40''$, that *Vega* $\alpha$ is refracted 40″ more than Sun F. $(r\alpha)$ means the angle between the minimum-refracted end of the stellar spectrum with its stria $\alpha$; $(\alpha\beta)$, $(\beta\gamma)$, the angles between $\alpha$ and $\beta$, $\beta$ and $\gamma$. $(\alpha v)$, $(\beta v)$, $(\gamma v)$, are the angles made by $\alpha$, $\beta$, and $\gamma$, with the maximum-refracted end $v$ of its spectrum.



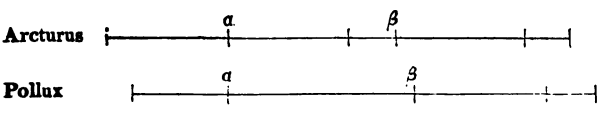

White Stars:—



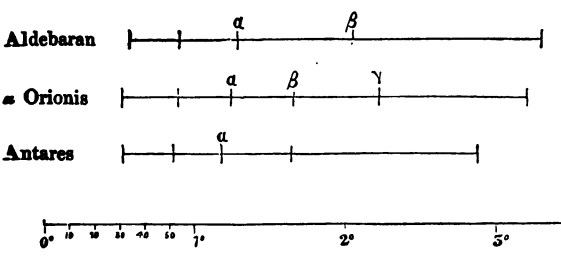

Yellow Stars:—




Orange Stars:—




Red Stars:—



A short description of each stria is appended, and its eye-estimated breadth referred to the micrometric bars. These said angles do not correspond to the central part of the striæ, but to their least refracted limb, which limb I always collimated with the movable bar of the micrometer. Thus *Sirius* $\alpha$ is refracted 15″ less than F Sun; but, since breadth of this $\alpha = 50''$, the central part of the said $\alpha$ is refracted 10″ more than F Sun. Similarly *Vega* $\alpha = F \odot + 40''$, breadth 40″, has its centre refracted 60″ more than F Sun, &c.

| | | $(r\alpha)$ | $(\alpha\beta)$ | $(\beta\gamma)$ | $(\gamma v)$ |
|---|---|---|---|---|---|
| Sirius | $\alpha = F \odot - 15''$ | 85′ 40″ | 66′ 37″ | 42′ 27″ | 20′ 17″ |

$\alpha$ very fine, breadth 50″; $\beta$ very fine, double, breadth 80″; $\gamma$ as broad as $\alpha$, faint.

| | | | | | |
|---|---|---|---|---|---|
| Vega | $\alpha = F \odot + 40''$ | 77′ 15″ | 67′ 56″ | 34′ 55″ | 10′ 18″ |

$\alpha, \beta$, very fine; $\alpha$ 40″, $\beta$ 60″ broad; $\gamma$ very broad, faint.

| | | | | | |
|---|---|---|---|---|---|
| Procyon | $\alpha = F \odot - 33''$ | 78′ 55″ | 65′ 30″ | 37′ 1″ | 9′ 32″ |

$\alpha$ well seen, 15″ broad; $\beta$ scarcely seen; $\gamma$ ditto, rather broader than $\alpha$.

| | | | | | |
|---|---|---|---|---|---|
| Regulus | $\alpha = F \odot - 60''$ | 68′ 30″ | 66′ 17″ | 30′ 55″ | — |

$\alpha$ very clear, 20″ broad; $\beta$ seen at intervals.

| | | | | | |
|---|---|---|---|---|---|
| Fomalhaut | $\alpha = F \odot - 55''$ | 61′ 44″ | 70′ 36″ | — | — |

$\alpha$ fine, 35″ broad.

| | | | | | |
|---|---|---|---|---|---|
| Castor | $\alpha = F \odot - 30''$ | 69′ 43″ | 62′ 4″ | 30′ 9″ | — |

$\alpha$ very fine, 40″ broad; $\beta$ ditto, 60″ broad.

| | | | | | |
|---|---|---|---|---|---|
| Altair | $\alpha = F \odot + 5''$ | 73′ 42″ | 66′ 3″ | 24′ 23″ | — |

$\alpha$ fine, 20″ broad; $\beta$ indistinct, faint, 40″ broad.

| | | | | | |
|---|---|---|---|---|---|
| Capella | $\alpha = F \odot - 2'40''$ | 81′ 1″ | 31′ 55″ | 34′ 35″ | 23′ 36″ |

$\alpha$ very thin, well observed; $\beta, \gamma$, scarcely visible, uncertain observation.

| | | | | | |
|---|---|---|---|---|---|
| Arcturus | $\alpha = F \odot - 29'22''$ | 51′ 26″ | 44′ 27″ | 66′ 23″ | — |

$\alpha$ very thin, seen with trouble; $\beta$ very difficult to be seen.

| | | | | | |
|---|---|---|---|---|---|
| Pollux | $\alpha = F \odot - 28'42''$ | 47′ 33″ | 45′ 46″ | 68′ 56″ | — |

$\alpha$ very thin, seen with trouble; $\beta$ very difficult to be seen.

Aldebaran $\alpha$ = F ⊙ − 22′29″ 50′39″ 29′40″ 64′17″ —

$\alpha$ very fine, 30″ broad; $\beta$ somewhat thinner than $\alpha$, very fine.

$\alpha$ Orionis $\alpha$ = F ⊙ − 30′35″ 50′19″ 17′24″ 16′51″ 57′18″

$\alpha$ very fine, 40″ broad; $\beta$ very fine, 50″ broad; $\gamma$ frothy, well seen.

Antares $\alpha$ = F ⊙ − 33′28″ 47′20″ 18′17″ 65′45″ —

$\alpha$ fine, 30″ broad; $\beta$ rather fine, 20″ broad.

Now, comparing my results with Fraunhofer, there are very great differences. Thus, he says, *Sirius* has a very fine stria in the green, whilst I find this stria in the blue of the spectrum. He finds in *Pollux*, *Capella*, *α Orionis*, *Procyon*, a stria with the same position as D Sun, which line I have never seen. Perhaps attributable to the reason that the stellar light is never strong enough to distinguish the colours; saving a reddish tinge at the minimum-refraction end, they appear of a lavender tint in their whole length, which is always smaller than the solar one under the same conditions, from the great difference of light between the Sun and stars. If the stellar stria has not been measured, but merely eye-estimated (probably Fraunhofer's process), one may very easily get deceived, and mistake one stria for another. This occurred even to me at the beginning. Thus comparing the distance between the extreme red of *Sirius* and its $\alpha$ with that between the extreme red of the Sun, and E ⊙, I judged that $\alpha$ *Sirius* = E ⊙; but, passing to exact measures, I directly found that $\alpha$ *Sirius* = F ⊙.

Perhaps, as the stars change in colour, their stria-positions may change, or my more brilliant striæ may not have been the more brilliant ones to Fraunhofer's eye. (Thus Fraunhofer is silent on the difficulties of *Capella*, and speaks of the difficulties of *Procyon*. I found *Capella* very troublesome, and the stria of *Procyon* much clearer and sharper than any in *Capella*.) I merely point out the utility of making these observations at various times with the extremest accuracy, without hazarding any hypothesis.

However, I must remark that almost all my fifteen stars have a stria, very little differing from F ⊙. One may therefore presume that all these F-like striæ are constant, but with a greater or less refraction, from a difference in the refractive quality of the light of the particular star. On this hypothesis (partly agreeing with Fraunhofer's), it follows that the light of *Capella*, with a stria refracted 2′ 40″ less than F ⊙, must suffer a less refraction than the light of *Vega*, which is refracted 60″ more than F ⊙, whence the declinations of those two stars,

observed from two places, with very different (meridian) altitudes for each, must result differently. (Since $2' 40'' + 60'' = 220''$, and the refraction of $F \odot = 51° 13' = 3073'$, with an horizontal refraction of $33'$. Hence the different refractions of these two striæ transferred to horizontal refraction $= \frac{33}{3073} + 220'' = 2''{\cdot}36$). I, therefore, compared Mr. Airy's *Cambridge Observations*, 1828–1835, with Mr. Henderson's, at the Cape of Good Hope, 1832–3 (*Mem. R. Ast. Soc.* vols. x. and xi.), which give these results:—

| Camb.—C.G.H. 1830. | | Mean Declination. Camb. 1830·0. | C.G.H. 1833·0. | A.P.M. in Decl. |
|---|---|---|---|---|
| ″ | | ° ′ ″ | ′ ″ | ″ |
| +1·94 | Fomalhaut | −30 31 13·92 | 30 19·1 | −0·166 |
| +1·71 | Antares | −26 0 46·81 | 3 14·3 | −0·034 |
| +0·81 | Sirius | −16 29 22·22 | 29 36·2 | −1·198 |
| +1·12 | Spica | −10 16 15·60 | 17 13·7 | −0·040 |
| +0·57 | Rigel | − 8 24 16·22 | 24 2·9 | −0·012 |
| −0·06 | Procyon | + 5 39 14·65 | 38 48·5 | −1·023 |
| +0·28 | α Orionis | + 7 22 3·72 | 22 7·1 | +0·002 |
| +1·32 | Altair | + 8 25 33·75 | 25 59·6 | +0·380 |
| +0·07 | Regulus | +12 47 44·17 | 46 49·1 | +0·006 |
| −0·51 | Aldebaran | +16 9 35·68 | 9 59·6 | −0·174 |
| +1·43 | Arcturus | +20 4 16·41 | 3 18·0 | −1·983 |
| +0·72 | Pollux | +28 25 45·50 | 25 20·4 | −0·057 |
| +0·49 | Castor | +32 15 9·44 | 14 47·2 | −0·078 |
| +1·88 | Vega | +38 37 50·56 | 37 57·7 | +0·282 |
| −2·00 | Capella | +45 48 51·88 | 49 8·4 | −0·425 |

I have extracted the Annual Proper Motion from vol. ii. p. 199, of *Annals of the Paris Observatory*. With them and the values in p. 181, to calculate the Precession, I have reduced the Cape Observations to 1830·0, whence I find as above. Whence *Vega* has at Cambridge a greater Declination than at the Cape of Good Hope, and *Capella* a less Declination at Cambridge. This seems to agree with my supposition, since *Vega* is low at the Cape with great horizontal refraction, and at Cambridge it is very high, with scarcely any refraction; and since the light of *Vega* seems from the above to be refracted more than the light of any other star, the refraction correction used at the Cape (which would increase the declination) is too small, making the star's declination less than that observed at Cambridge. The same horizontalities being verified for *Capella*, but, as contrary to *Vega*, the light of *Capella is less refracted* than that of *Vega*, the refraction correction

for the Cape of Good Hope must be too great for this star, causing a greater Cape of Good Hope declination than at Cambridge, as is the case. I chose the above two Catalogues, as being much esteemed and in approximate years: thus eliminating the uncertain influences of stellar Proper Motion. Also the stria *Vega* $\alpha$ is very fine, and *Capella* $\alpha$, though thin and difficult, has been often observed by me with sufficient precision. This does not occur with Fomalhaut, which, rising to a very small altitude above Florence, and only seen for a short time, has been seldom observed by me, causing with its horizontal scintillations unreliable results. Indeed, my observations would lead to a contrary sign of the difference in declination between Cambridge and the Cape of Good Hope than to that which is actually obtained.

The sign for *Sirius* should be +, since the centre of its $\alpha$ is refracted 10″ more than F ⊙; the refraction correction applied to this star's observed place may be smaller than the true one, when the observed declination at Cambridge has not been increased enough, giving a smaller result at the Cape of Good Hope. The difference, *Altair* + 1″·32, also confirms my hypothesis; for, since the centre of its $\alpha$ stria is refracted 20″ more than F ⊙, one may suppose the horizontal refraction to be less than the true one, causing the Cambridge declination to be increased, and the Cape of Good Hope declination diminished; and, therefore, the former greater than the latter.

My measures are uncertain, more from the difficulty of hitting the exact stria-point than from the micrometer graduation stopping at 6″·6. The quickest way of reconciling the two Catalogues would be to make simultaneous observations at both places.

I would further recommend for observations of the stellar striæ a very large lens on Fresnel's principles for lighthouse lenses, as we do not so much require an image of achromatic sharpness as the concentrating of a great quantity of light, and such a lens would, perhaps, enable us to see as many stellar striæ as we find in the solar spectrum.

We further require to know the very small dispersive power in our atmosphere of the stellar light; also the stellar spectra breadth seen when near the horizon by a good telescope; also the maximum brightness point of various spectra. Such a series would be of first-rate value to modern Astronomy.

The second Memoir, dated February 1861, contains the author's observations of the Total Solar Eclipse of 1860, at Terrablanca, in Spain; and the third Memoir contains the Comet Observations at Florence, from 1854 to 1860.

*Remarks upon the Phenomena attending the Disappearance, by Rotation, of the great Solar Spot of August 4th, 1862, as recorded by both Helio-photography and ordinary Telescopic Observation.* By the Rev. F. Howlett.

Mr. Howlett, at the December Meeting, addressed the Society as follows:—

After the able remarks which have recently appeared in print respecting the comparative merits, in certain points, of celestial photography and telescopic observation—in connexion chiefly with the solar, and also the lunar surface—it might be deemed almost more than superfluous on my part to wish to bring the subject again before your attention this evening.

Mr. Dawes has alluded to the matter in a very instructive manner, both in an article which appeared in the *London Review* on the 18th of October last, and elsewhere; as also has Mr. Birt, in the columns of the same journal for Nov. 22 of the present year.

But the phenomena attending the disappearance, by rotation, of the very remarkable group of solar spots on the 4th of August last, and the observations then made, photographic and otherwise, in connexion with those phenomena, seem to bear so strongly upon one or two of the more *interesting* and at the same time most *warmly contested* points regarding the Sun's surface, that I hope I shall be pardoned for desiring to make you acquainted with the nature of a few of my own observations concerning the disappearance of this said group, as contrasted with the only photographic record of it which I have yet heard of, more especially since I was, I believe, the first to detect the discrepancy in this particular instance, in the course of a most interesting correspondence, which now for some little time has been maintained between Professor Selwyn and myself on such subjects; and I was permitted to make the case known in public on the 3d of October, before the members of the British Association assembled at Cambridge—as some here present may possibly remember.

It will of course be understood that it is in no carping spirit (which on every account would utterly unbecome me) that I venture to say that at times the photographic record may stand corrected by the simply telescopic one; the highest honours of this Society have recently, and doubtless most justly, been awarded to that distinguished member of our Society, whom we have now the great good fortune to own as one of our Secretaries, for his extraordinary success in applying the art of photography to celestial investigations of the highest interest; and earnestly do we all wish him every future success therein also, that both he and every lover of science could possibly desire.

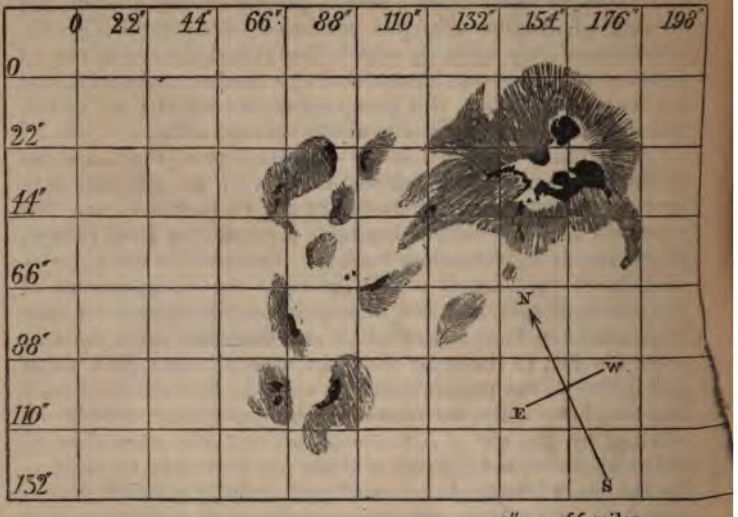
But not to be further tedious I would at once proceed to

remark, that the magnificent group in question (lettered $\varrho$ in my record of Solar Spots), which passed off the disk on the evening of August 4th, was not observed by me before the afternoon of July 25th, by which time it had already advanced a considerable distance upon the Sun's surface. As seen near the centre of the disk, this group subtended about 4′ 30″ of arc, which would be equivalent to about 122,000 miles.

A carefully sketched series of drawings of the same, including twenty-two delineations, taken upon ten different days (and which are seen in sheets 83 to 86 inclusive), may be compared with the helio-autographs presented by Prof. Selwyn to the Royal Astronomical Society. Some of the drawings—those more particularly which illustrate the disappearance of the principal spot, and the photographic discrepancy on that occasion, have been re-copied in the diagrams on a scale of about ten feet to the solar diameter, which would give about four inches to one minute of arc, an amplification which, though not the best truly for distinct definition, may readily be obtained by the aid of a telescope of even not more than $2\frac{3}{4}$ inches aperture, and a power of about 160 diameters, by projecting the Sun's image upon a cardboard or other suitable screen, placed in a perfectly darkened chamber, at a distance of 8 feet from the eye-glass; and which arrangement enables me to observe and study the faculæ and solar surface generally, with remarkable facility and satisfaction. But the most effectual definition, amplification, and general management of the whole apparatus of both telescope, screen, and darkening shutter, are obtained in a simple but instructive method, by placing the screen on an easel, at the distance of about 4 ft. 2 in. from the eye-glass of my telescope—either one of the equatoreally mounted Sheepshanks' instruments, No. 4, belonging to the Royal Astronomical Society, $3\frac{3}{4}$ inches aperture, and 3 ft. 8 in. focal length, or a small Dollond of my own, of admirable definition and similar focal length, but of only $2\frac{3}{4}$ inches aperture, mounted upon a tripod stand, and armed with powers from 30 to 150 diameters. With a power of 80 diameters, the graduations of a kind of glass micrometer, ruled off into $\frac{1}{100}$ths of an inch, are seen beautifully projected upon a screen thus placed, (as also are any sun-spots or other solar phenomena that may chance to be in the field) each graduation meanwhile measuring half an inch in breadth, and comprising about 31 seconds of arc.

With regard, next, to the appearance of the group on July 25th, at $1^h\ 30^m$ P.M., I would direct attention to a remarkable mass of brilliant photospheric matter, at least 12,000 miles in length by 6,000 miles in breadth, (and embracing therefore a superficial area of not less than seventy-two million square miles), lying amidst the various associated nuclei of the principal spot, and completely insulated by a well-defined penumbra from *the contiguous photosphere* (fig. 1).

Fig. 1, 1862, July 25, 2·0 P.M.



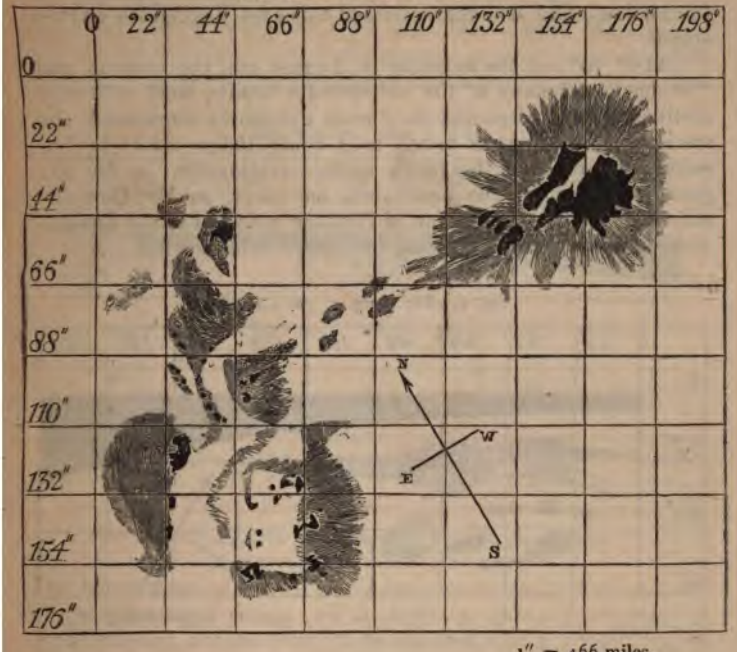

1″ = 466 miles.

On July 26th these nuclei had run into each other and become considerably enlarged, at the expense apparently of the bright patch; which last, either by sublimation, possibly, or a draining off sideways, or some kind of exhaustion, had become very much reduced in magnitude, as it was still more by $7^h\ 30^m$ A.M. on July 27th (see fig. 2), whilst, by $3^h\ 0^m$ P.M. on the same day, the patch was nearly obliterated, a slight hazy "bridge" alone remaining visible, and which in a feeble diffused form was faintly to be traced also on both the 28th and 29th July; but when I next observed the Sun on the 31st, this haze seemed to have entirely vanished. Some have thought that such a hazy film constantly accompanies a nucleus, but such is not my own impression. May not any extra appearance of haze be rather accounted for by the occurrence of phenomena similar to those which have just been described?

On July 31st, and August 1st, the great nucleus was grandly fringed by projections from the contiguous penumbral matter, often with sharp tooth-like terminations, and the disposition of the subordinate spots and patches of penumbra was also very interesting and instructive, as indeed they had been during the whole period of their apparition. But the highest point of interest, perhaps, in connexion with this group, exhibited itself on the occasion of the gradual disappearance round the western limb on the evening of August 4th.

On the preceding day, indeed, the group, and more especially the principal nucleus, might be seen to be remarkably *foreshortened*, and to be about to be divided again, apparently

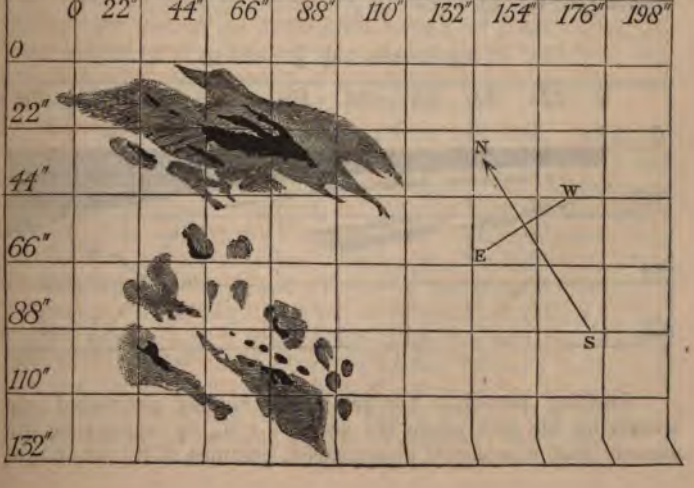
Fig. 2, 1862, July 27, 7·30 A.M.




1″ = 466 miles.

into two portions, by a sharply-defined and fresh "bridge," projecting across the chasm from the northern side (see fig. 3),

Fig. 3, 1862, Aug. 3, 6·40 A.M.



which feature (though springing then from the western side of the nucleus) had also characterised this spot during its earlier stages.

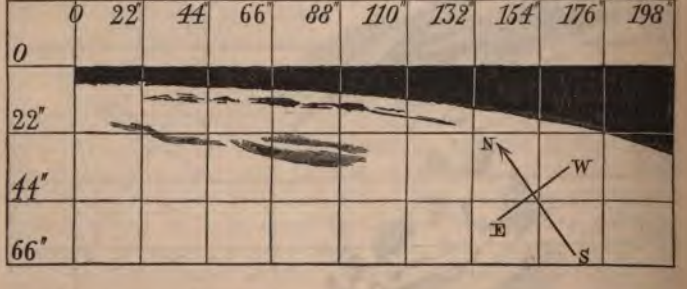
At $6^h\ 30^m$, on the morning of August 4th, the nucleus and "bridge," and many of the subordinate details, were still very distinct, though of course they were extremely attenuated, the nucleus then being, as nearly as I could judge, about twelve seconds of arc from the Sun's north-west margin; by far the greater portion of the penumbra, moreover, as Mr. Birt observed in his communication of October 20th last to the *London Review*, lying on its following or eastern side (see fig. 4).

Fig. 4, 1862, Aug. 4, 7h0 A.M.

1″ = 466 miles.

By $3^h\ 50^m$ P.M., the nucleus, now reduced to a mere line, yet (owing to the admirable state of the atmosphere that day in east Sussex) *clearly* to be distinguished from its adjoining penumbra, could not have been more than from 3″ to 4″ from the limb, which latter, however, as yet, was certainly not broken (see fig. 5).

Fig. 5, 1862, Aug. 4, 3·50 P.M.

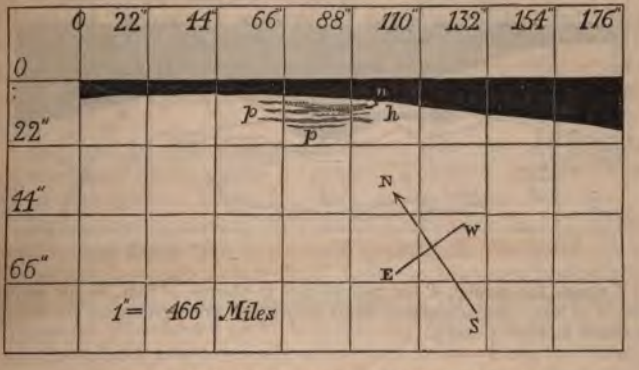



Pressing parochial business unfortunately prevented my observing the disk again till about 6 P.M., by which time the nucleus had completely disappeared, portions of its penumbra,

however, still remaining visible, as well as other patches of penumbræ adjoining.

And now it was that I am confident I could plainly perceive a *small notch* in the Sun's margin, precisely over the place where the great nucleus must have been existing (see fig. 6): and

Fig. 6, 1862, Aug. 4, 6 P.E.



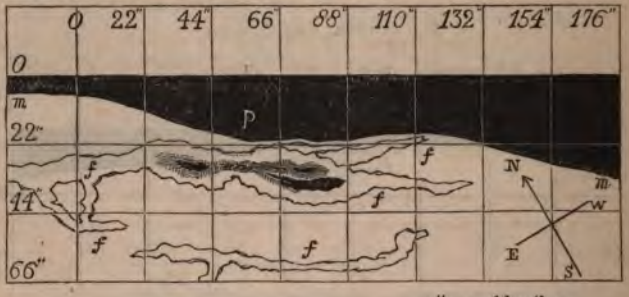

*n*, true notch in Sun's margin; *h*, hillock of facula;
*p*, penumbral patches of great group.

it struck me that it was not caused so much by any deficiency in the circular limb of the Sun itself, but rather by reason of abnormally heaped up masses of the contiguous photosphere; which had perhaps been swept away, as it were, from the area occupied by the nucleus and penumbra, in like manner as a slight fall of snow might have been swept away from off a gravel path, and thus have been thrown up a little on each side. The portion of penumbra, in fact, which still remained visible, appeared to me to form the bottom of a shallow valley, seen obliquely over one of the elevations by which it was bounded, the right-hand, or south, bank (as seen in the inverted image) being the higher of the two.

Now all the foregoing observations had been communicated by me in a letter to Prof. Selwyn before I had any knowledge whether or no his photographer (Mr. Titterton, of Ely) had obtained "autographs" of the Sun on the day in question. A reply to my letter came to me shortly afterwards, in the form of two separate "autographs," taken respectively at the hours of $10^h\ 15^m$ and $11^h\ 30^m$ of the notable morning of August 4. But what struck me as very remarkable, was, that at the time when I had plainly observed and measured a brilliant streak of photosphere extending between the nucleus and the Sun's limb (and which I continued to observe and measure, at intervals, for nine hours afterwards), the autographs presented no appearance whatever of this streak, but

exhibited instead the appearance of a large notch or depression in the limb, approximately about 2′ of arc in length from N. to S., and 15″ or 16″ in depth from E. to W. See Fig. 7.

Fig. 7, 1862, Aug. 4, 10·30 A.M. (as represented in photograph).




1″ = 466 miles.

*f* stands for faculæ, P for pseudo gap in margin of Sun, *m* for normal margin of Sun; the subordinate spots only of the great group are yet visible, as shown in Figs. 4 and 5.

But this extraordinary depression, though hailed at the first by some of the advocates of the cavernous nature of the solar spots, as an almost triumphant proof of their views, went, as we have just seen, to prove *too much;* and, indeed, had the collodion been exposed to the solar rays for a somewhat longer period, in order that the comparatively dusky solar margin might have sufficiently depicted itself, no notch of any such dimensions (or, indeed, any notch at all) could possibly have appeared; and though Prof. Selwyn believes that this lengthened exposure would have spoiled, in all probability, the middle portions of the photograph (where, for instance, in sheet 86, the group lettered $\sigma$ in my record is situated), yet in such a case it would only be requisite of course to take other negatives more especially adapted to the central parts of the disk.

Whilst on this part of my subject I would take the opportunity of mentioning that the helio-autographs of August 4th are not the only instances which present the appearance of such a pseudo-gap in the Sun's margin, whereby the existence of a large spot, when close to the limb, is completely ignored, sometimes.

Another such instance occurred in the photograph taken by Mr. Titterton on October 1st. Several of those who were attending at that time the meeting of the British Association, at Cambridge, would gladly have availed themselves of another of those rarely occurring chances of watching a large group fairly off the disk. Mr. Alexander Herschel did have such an opportunity at Collingwood, near Hawkhurst, that day, though

no notch was at any time apparent. Previously to leaving home I had requested Mr. Herschel to keep an eye on the group in question, and I received from him a letter, from which the following is an extract:—

"*Collingwood, Hawkhurst,*
"*Oct. 1st*, 1862.

"I send you in reply . . . a sketch of the Sun's appearance to-day. I missed the breaking of the white line, but the scale of the sketch, which is 1 inch to a minute, will show you that I saw it at $10^h\ 50^m$ A.M., to within 5 or 6 seconds of the Sun's limb, without any signs of the white line breaking."

And yet in the photograph taken that day at Ely the principal spot of the group is ignored, a shallow notch occupying its place, when, in point of fact, no such notch existed.

But notwithstanding any such discrepancies, allow me here to plead for the cavernous nature of the solar spots. For whilst jealously avoiding all desire to take any undue kind of argument from helio-photography, in its present stage, in support of the theory (which is also my own firm persuasion), that the solar spots are indeed cavities in the Sun's surface, I am not willing to be shaken in my belief that the photographic testimony bears most strongly in favour of that theory.

Photography, indeed, at times, would seem to wish to prove too much, as we said, but all its evidence, surely, runs in the same direction. It proves, surely, in agreement with the best eye observations, that the faculæ *undoubtedly* are raised billows or mountains, as it were, of photospheric matter, the crests of which (as Padre Secchi pointed out to me when lately at Rome) are necessarily not very visible when situated in the more *central* parts of the disk, where they are seen through the least perspective depth of the solar atmosphere, and where, in consequence, all similarly luminous photospheric matter, whether raised or otherwise, appears nearly alike brilliant; but which faculæ naturally exhibit themselves in far stronger relief towards the *marginal* portions of the disk, because that the rays which emanate from their lofty crests have to traverse, in their passage to our eyes, a far smaller amount of solar atmosphere than those rays have which emanate from their bases, and from the mean photospheric level above which the faculæ rise.

But may it not be argued thus, also, that not only are the faculæ elevations, but that the nuclei and penumbræ are depressions in the solar surface, and not clouds impending over it?

For if the solar spots were clouds, would they not (especially when anything like the size of the group of August 4th, 1862) exhibit much more frequent appearances of notches than they do?

They would surely be often seen in dark relief upon the Sun's limb, something after the way in which, at the beginning or close of a transit, the planets *Mercury* or *Venus* may be seen to produce an apparent indentation. And this appearance ought to take place, in the case of spots or groups of large magnitude, whether they were at a greater or less distance from the Sun's surface. Whereas, supposing them to be indeed cavities sunk in the spherical solar orb, then it seems clear that, even with the addition of the upheaved faculæ to enhance the effect, the phenomenon of a notch must be, *as it is*, exceedingly *rare*, and without the faculæ be well-nigh impossible.

But all the conditions requisite for forming the appearance of a small depression in the Sun's Limb were fulfilled on the evening of 4th of August. A group of unusual magnitude was passing off: there were mountain-like ridges of faculæ plainly conspicuous in the immediate neighbourhood of the same, and the eye of a spectator upon the earth would be looking along the shallow *trough* of the solar penumbræ, nucleus, and faculæ, in its greatest extent.

Another objection, finally, to the spots being cloudy masses appears to be this. Would it be possible for clouds to maintain such a comparatively *black tint* when immediately superimposed over the intensely incandescent surface (if it be incandescent, really, as well as brilliant) of the orb of the Sun?

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## RECENT PUBLICATION.

*Sur deux Inégalités d'une grandeur remarquable dans les Apparitions de la Comète de Halley.* Par A. J. Angström. (Extrait des *Actes de la Société Royale des Sciences d'Upsal*, Sér. iii. t. iv.) Upsal, 1862.*

The author remarks that Mr. Hind having succeeded in obtaining from the ancient accounts the appearances of Halley's Comet, as far back as the year 10 B.C., with considerable probability, he (M. Angström) was by these dates enabled to show the existence of two periodic Inequalities in the time of revolution of the Comet, surpassing as well in their magnitude as in the length of their period all the known Inequalities in the Planetary and Lunar Theories. The greater inequality, as regards the time of revolution of the Comet, is the more interesting, inasmuch as it depends on the known relation

* Mr. Carrington gave an account of this Memoir at the January Meeting, and he particularly called attention to the comparatively small amount of labour expended in obtaining such important results.—Ed.

(5 *Sat.* — 2 *Jup.* = 0 nearly) between the times of revolution of *Jupiter* and *Saturn*. The assumed data were—

*Times of the Appearances of the Comet according to Mr. Hind.*

| | | | |
|---|---|---|---|
| — 10,20 | 451,50 | 912,25 | 1378,85 |
| + 66,07 | 530,84 | 989,70 | 1456,44 |
| 141,24 | 608,80 | 1066,25 | 1531,65 |
| 218,26 | 684,80 | 1145,30 | 1607,82 (N. S.) |
| 295,25 | 760,44 | 1223,52 | 1682,70 |
| 373,84 | 837,26 | 1301,81 | 1759,19 |
| | | | 1835,87 |

thus comprising 24 complete revolutions, and giving a mean period

$$\tau = 76{,}92 \quad \text{Julian years};$$

or, taking the Julian year for the unit of time, the mean velocity of the Comet is $= 4^\circ\, 40'\, 48''{\cdot}72$.

Taking, then, the mean year 913,97 as the epoch, and the above value $\tau = 76{,}92$ as the mean time of revolution, this gives for the differences between the actual and calculated times of appearance, reckoned in Julian years, the series of values (already calculated by M. Mädler):—

| | | | |
|---|---|---|---|
| −1,13 | −0,95 | −1,72 | +3,27 |
| −1,78 | +1,47 | −1,18 | +4,04 |
| −3,53 | +2,51 | −1,55 | +2,31 |
| −3,45 | +1,59 | +0,58 | +1,48 |
| −3,36 | +0,27 | +1,88 | −0,46 |
| −1,69 | +0,21 | +3,25 | −0,89 |
| | | | −1,13 |

These differences are laid down as ordinates in the plate annexed to the Memoir, the unit of distance for the abscissæ being the mean period $\tau$, and that for the ordinates the half of a Julian year. And the form of the broken line joining the extremities of the ordinates, suggests the existence of the two inequalities (reckoned in Julian years):—

$$= 1{,}5 \sin\left((13\ \text{Com.} - 2\ \text{Jup.})\, n\tau + 13^\circ{\cdot}6\right)$$

$$\propto 2{,}3 \sin\left((\text{Jup.} + \text{Sat.} - 9\ \text{Com.})\, n\tau + 231^\circ\ 1'\right)$$

the former depending exclusively on *Jupiter*, but the latter on *Jupiter* and *Saturn* conjointly.

A numerical discussion of the data by the method of least squares, on the foregoing basis, leads to the corrected formula for the time of appearance:—

$$A = 913{,}97 + n\tau + 1{,}4626 \sin\left((13\ \text{Com.} - 2\ \text{Jup.})\, n\tau + 19^\circ\, 14'{\cdot}3\right) + 2{,}1642 \sin\left((\text{Jup.} + \text{Sat.} - 9\ \text{Com.})\, n\tau + 233^\circ 39'{\cdot}1\right),$$

with the corrected value $\tau = 76{,}93$, and resulting value $4^\circ\, 40'\, 46''{\cdot}6$ for the period and mean annual velocity of the Comet; and then with Hansen's values,

$$\text{Jup.} = 30^\circ\, 20'\, 56''{\cdot}7, \qquad \text{Sat.} = 12^\circ\, 36'\, 16''{\cdot}1,$$

the numerical values for the arguments are found to be

$$13\ \text{Com.} - 2\ \text{Jup.} = 8'\, 10''{\cdot}4 = 2649{,}7\ \text{Jul. years} = 34{,}44\ \tau$$
$$\text{Jup.} + \text{Sat.} - 9\ \text{Com.} = 27'\, 15''{\cdot}2 = 782{,}38\ \text{,,} = 10{,}30\ \tau.$$

The final comparison of the formula with the data is found to present a very satisfactory accordance. The author remarks that by the combined action of the two inequalities, *the time of appearance of the Comet might be accelerated or retarded* from one revolution to another, *by about a year and a half.*

---

*Minor Planet* (78). Discovered by Dr. C. H. F. Peters, at the Hamilton College Observatory, 22d Sept. 1862.

The following elements, calculated by him, are given (*Ast. Nach.* No. 1399):—

Epoch 1862, Nov. 0·0, Washington M.T.

| | | ° | ′ | ″ | |
|---|---|---|---|---|---|
| M | = | 30 | 0 | 10·93 | |
| $\pi$ | = | 334 | 40 | 12·13 | Mean Equinox 1862·0. |
| $\Omega$ | = | 359 | 52 | 19·09 | |
| $i$ | = | 4 | 59 | 8·75 | |
| $\varphi$ | = | 17 | 47 | 7·24 | |
| $\mu$ | = | | | 815″·1760 | |
| log $a$ | = | | | 0·4258368 | |

***Minor Planet* (76) *Freia.*** Discovered by Prof. D'Arrest, at Copenhagen, 14th Nov. 1862.

The following elements are given by him (*Ast. Nach.* No. 1397):—

Epoch 1862, Oct. 24·5, Greenwich M.T.

| | | | |
|---|---|---|---|
| M | = | 329° 35′ 4″·4 | |
| $\varpi$ | = | 94 5 52·1 | Mean Equinox 1862·0. |
| $\Omega$ | = | 213 58 4·3 | |
| $i$ | = | 1 45 11·1 | |
| $\varphi$ | = | 23 30 37·0 | |
| log $a$ | = | 0·599052 | |
| $\mu$ | = | 448″·156 | |

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A proposal has been made to form an Association for the Systematic Observation of Variable Stars. Members of the Society and others who may feel interested in the subject are respectfully requested to communicate with George Knott, Esq., Observatory, Cuckfield, Sussex, or Joseph Baxendell, Esq., 108 Stocks Street, Manchester.

---

*Instruments to be disposed of.*

A fine mahogany Telescope Tube suitable for a 7½-in. or 8-in. Object-glass, having a focal length of 9½ to 10½ feet; counterbalances, rackwork, illuminating apparatus, and finder; with a 2-in. object-glass, complete. This tube has been used for a 7½-in. object-glass, and was fitted up by Messrs. Dollond. Apply to Mr. Cooke, 31 Southampton Street, Strand, London, where the Tube may be seen.

The original Telescope and its Equatoreal Mounting of the late Dr. Pearson. The object-glass is nearly 7 ins. in diameter, and 12 feet in focal length. This Telescope is fully described and reported upon in the *Memoirs of the Royal Astronomical Society*, vol. ii. page 507. Apply to G. L. Prince, Esq. F.R.A.S., Uckfield, Sussex.

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# MONTHLY NOTICES

OF THE

# ROYAL ASTRONOMICAL SOCIETY.

VOL. XXIII. *February* 13, 1863. No. 4.


THE Annual General Meeting of the Society, Dr. LEE, President, in the Chair.

Rev. Samuel F. Cresswell, Durham;
Major M. Foster Ward, Castle House, Calne, Wilts;
James L. Shuter, Esq., 33 Farringdon Street; and
William Esson, Esq., Merton College, Oxford,

were balloted for and duly elected Fellows of the Society.

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*Report of the Council to the Forty-third Annual General Meeting of the Society.*

The Report of the Auditors, subjoined, will show the state of the finances:—

RECEIPTS.

| | £ | s. | d. |
|---|---|---|---|
| Balance of last year's account | 171 | 9 | 1 |
| By dividend on £2100 Consols | 30 | 6 | 5 |
| By ditto on £3850 New 3 per Cents | 55 | 11 | 9 |
| By ditto on £2100 Consols | 30 | 6 | 5 |
| By ditto on £3850 New 3 per Cents | 55 | 11 | 9 |
| On account of arrears of contributions | 84 | 0 | 0 |
| 129 contributions (1862–63) | 270 | 18 | 0 |
| 3 compositions | 63 | 0 | 0 |
| Carried forward | £761 | 3 | 5 |

| | £ | s. | d. |
|---|---|---|---|
| Brought forward | 761 | 3 | 5 |
| 29 admission-fees | 60 | 18 | 0 |
| 26 first year's contributions | 44 | 2 | 0 |
| 2 contributions for 1864 and 1865 | 4 | 4 | 0 |
| Sale of Publications | 169 | 14 | 10 |
| By interest on money for India Hill Observatory | 29 | 16 | 5 |
| | £1069 | 18 | 8 |

## EXPENDITURE.

| | £ | s. | d. | £ | s. | d. |
|---|---|---|---|---|---|---|
| **Salaries:—** | | | | | | |
| Mr. Cayley, 1 year as Editor of the Society's Publications | 60 | 0 | 0 | | | |
| Mr. Williams, 1 year as Assistant-Secretary | 100 | 0 | 0 | | | |
| Ditto commission on collecting £631 14*s.* 10*d.* | 29 | 5 | 0 | | | |
| | | | | 189 | 5 | 0 |
| **Investments:—** | | | | | | |
| Purchase of £50 New 3 per Cents | 46 | 9 | 0 | | | |
| Ditto £50 New 3 per Cents | 46 | 1 | 3 | | | |
| | | | | 92 | 10 | 3 |
| **Taxes:—** | | | | | | |
| Income Tax, 1 year | 1 | 17 | 6 | | | |
| Ditto on E. I. Coupon | 0 | 7 | 6 | | | |
| Assessed and Land, 1 year | 4 | 9 | 2 | | | |
| | | | | 6 | 14 | 2 |
| **Bills:—** | | | | | | |
| Strangeways and Co., printers | 243 | 12 | 0 | | | |
| J. Rumfitt, bookbinder | 36 | 5 | 3 | | | |
| J. Basire, engraver | 58 | 16 | 0 | | | |
| Maltby and Sons, lithographers | 37 | 18 | 10 | | | |
| Williams and Norgate, printing | 9 | 2 | 0 | | | |
| Deville, gasfitter | 4 | 12 | 6 | | | |
| Insurance (Sun Fire Office) | 12 | 5 | 6 | | | |
| | | | | 402 | 12 | 1 |
| **Miscellaneous items:—** | | | | | | |
| Charges on books, and carriage of parcels | 3 | 13 | 8 | | | |
| Postage of *Monthly Notices*, letters, &c. | 35 | 11 | 9 | | | |
| Porter's and charwoman's work | 24 | 1 | 3 | | | |
| Tea, sugar, biscuits, &c. for evening meetings | 13 | 13 | 0 | | | |
| Waiters attending meetings | 3 | 17 | 0 | | | |
| Coals, &c. | 12 | 0 | 0 | | | |
| Sundry disbursements by the Treasurer | 31 | 4 | 6 | | | |
| Sundry payments out of Turnor Fund | 5 | 13 | 0 | | | |
| Deduction on country cheque | 0 | 1 | 0 | | | |
| Mrs. Jackson's annuity, 1 year | 8 | 13 | 4 | | | |
| | | | | 138 | 8 | 6 |
| Balance at Banker's | | | | 240 | 8 | 8 |
| | | | | £1069 | 18 | 8 |

Assets and present property of the Society, Feb. 9, 1863:—

| | | | | £ | s. | d. |
|---|---|---|---|---|---|---|
| Balance at Banker's | | | | 240 | 8 | 8 |
| 4 contribution of | 5 years' standing | | 42 0 0 | | | |
| 9 ——— of | 3 | ditto | 56 14 0 | | | |
| 23 ——— of | 2 | ditto | 96 12 0 | | | |
| 64 ——— of | 1 | ditto | 134 8 0 | | | |
| | | | | 329 | 14 | 0 |
| Due for publications of the Society | | | | 2 | 1 | 8 |

£3850 New 3 per Cents. including Mrs. Jackson's gift (£300).
£2100 Consols, including the Lee Fund, (£100), and the Turnor Fund (£500).
Unsold publications of the Society.
Various astronomical instruments, books, prints, &c.
Balance of Turnor Fund (included in Treasurer's account) ... 69 16 10

Stock of volumes of the *Memoirs*:—

| Vol. | Total. | Vol. | Total. | Vol. | Total. |
|---|---|---|---|---|---|
| I. Part 1 | 21 | X. | 194 | XXI. Part 2 (separate). | 100 |
| I. Part 2 | 63 | XI. | 204 | XXI. (together). | 124 |
| II. Part 1 | 80 | XII. | 206 | XXII. | 202 |
| II. Part 2 | 44 | XIII. | 227 | XXIII. | 203 |
| III. Part 1 | 98 | XIV. | 324 | XXIV. | 210 |
| III. Part 2 | 119 | XV. | 193 | XXV. | 219 |
| IV. Part 1 | 120 | XVI. | 196 | XXVI. | 228 |
| IV. Part 2 | 131 | XVII. | 194 | XXVII. | 483 |
| V. | 147 | XVIII. | 193 | XXVIII. | 449 |
| VI. | 168 | XIX. | 207 | XXIX. | 482 |
| VII. | 191 | XX. | 200 | XXX. | 262 |
| VIII. | 177 | XXI. Part 1 (separate). | 316 | | |
| IX. | 181 | | | | |

Progress and present state of the Society:—

| | Compounders. | Annual Contributors. | Non-residents. | Patroness, and Honorary. | Total Fellows. | Associates. | Grand Total. |
|---|---|---|---|---|---|---|---|
| February 1862 ... | 164 | 232 | 31 | 4 | 431 | 49 | 480 |
| Since elected ..... | 3 | 21 | ... | 1 | ... | 1 | ... |
| Deceased ..... | −4 | −3 | ... | ... | ... | −3 | ... |
| Resigned ..... | ... | −3 | ... | ... | ... | ... | ... |
| Removed for non-payment | ... | −2 | ... | ... | ... | ... | ... |
| *February 1863* ... | 163 | 245 | 31 | 5 | 444 | 47 | 491 |

The instruments belonging to the Society are as follows:—

The *Harrison* clock,
The *Owen* portable circle,
The *Beaufoy* circle,
The *Beaufoy* transit,
The *Herschelian* 7-foot telescope,
The *Greig* universal instrument,
The *Smeaton* equatoreal,
The *Cavendish* apparatus,
The 7-foot Gregorian telescope (late Mr. Shearman's),
The Variation transit (late Mr. Shearman's),
The Universal quadrant by Abraham Sharp,
The *Fuller* theodolite,
The Standard scale,
The *Beaufoy* clock,
The *Wollaston* telescope,
The *Lee* circle,
The *Sharpe* reflecting circle.

The *Sheepshanks'* collection of instruments, viz.,—

1. 30-inch transit, by Simms, with level and two iron stands.

2. 6-inch transit theodolite, with circles divided on silver; reading microscopes, both for altitude and azimuth; cross and siding levels; magnetic needle; plumbline; portable clamping foot and tripod stand.

3. $4\frac{6}{10}$ achromatic telescope, about 5 feet 6 inches focal length; finder, rack motion; double-image micrometer; object-glass micrometer; two other micrometers; one terrestrial and ten astronomical eyepieces, applied by means of two adapters.

4. $3\frac{1}{4}$-inch achromatic telescope, with equatoreal stand; double-image micrometer; one terrestrial and three astronomical eyepieces.

5. $2\frac{3}{4}$-inch achromatic telescope, with stand; one terrestrial and three astronomical eyepieces.

6. $2\frac{3}{4}$ achromatic telescope, about 30 inches focus; one terrestrial and four astronomical eyepieces.

7. 2-foot navy telescope.

8. 45-inch transit instrument, with iron stand, and also Y's for fixing to stone piers; two axis levels.

9. Repeating theodolite, by Ertel, with folding tripod stand.

10. 8-inch pillar-sextant, divided on platinum, with counterpoise stand and horizon roof.

11. Portable zenith instrument, with detached micrometer and eyepiece.

12. 18-inch Borda's repeating circle, by Troughton.

13. 8-inch vertical repeating circle, with diagonal telescope, by Troughton and Simms.

14. A set of surveying instruments, consisting of a 12-inch theodolite for horizontal angles only, with extra pair of parallel plates; tripod staff; in which the telescope tube is packed, repeating table; level collimator, with micrometer eyepiece; and Troughton's levelling staff.

15. Level collimator, plain diaphragm.

16. 10-inch reflecting circle, by Troughton, with counterpoise stand; artificial horizon, with metallic roof; two tripod stands, one with table for artificial horizon.

17. Hassler's reflecting circle, by Troughton, with counterpoise stand.

18. 6-inch reflecting circle, by Troughton, with two counterpoise stands, one with artificial horizon.

19. 5-inch reflecting circle, by Lenoir.

20. Reflecting circle, by Jecker, of Paris.

21. Box sextant and 3-inch plane artificial horizon.

22. Prismatic compass.

23. Mountain barometer.

24. Prismatic compass.

25. 5-inch compass.

26. Dipping needle.

27. Intensity needle.

28. Ditto ditto.

29. Box of magnetic apparatus.

30. Hassler's reflecting circle, with artificial horizon roof.

31. Box sextant and $2\frac{1}{4}$-inch glass plane artificial horizon.

32. Plane speculum artificial horizon and stand.

33. $2\frac{1}{2}$-inch circular level horizon, by Dollond.

34. Artificial horizon roof and trough.

35. Set of drawing instruments, consisting of 6-inch circular protractor; common ditto; 2-foot plotting scale; two beam compasses and small T square.

36. A pentagraph.

37. A noddy.

38. A small Galilean telescope, with the object lens of rock-crystal.

39. Six levels, various.

40. 18-inch celestial globe.

41. Varley stand for telescope.

42. Thermometer.

43. Telescope, with the object-glass of rock crystal.

These are now in the apartments of the Society, with the exception of the following, which are lent, during the pleasure of the Council, to the several parties under mentioned, viz.:—

The *Wollaston* telescope, to Mr. Rees.
The *Lee* circle, to Mr. Burr.
The *Beaufoy* clock, to Dr. Booth.
The *Beaufoy* transit, to the Observatory, Kingston, Canada.

| | | |
|---|---|---|
| The *Sheepshanks* instrument, | | No. 1, to Mr. Lassell. |
| Ditto | ditto | No. 2, to Mr. De La Rue. |
| Ditto | ditto | No. 3, to Rev. C. Pritchard. |
| Ditto | ditto | No. 4, to Rev. F. Howlett. |
| Ditto | ditto | No. 5, to Mr. Birt. |
| Ditto | ditto | No. 6, to Rev. J. Cape. |
| Ditto | ditto | No. 8, to Prof. Wheatstone. |
| Ditto | ditto | No. 9, to Mr. Lockyer. |
| Ditto | ditto | No. 19, to Mr. Dayman. |
| Ditto | ditto | No. 25, to Mr. Dayman. |
| Ditto | ditto | No. 41, to Rev. C. Pritchard. |
| Ditto | ditto | No. 43, to Mr. Huggins. |

The 6-inch circular protractor, to Mr. Birt.

Nothing definite has yet been ascertained respecting the other *Beaufoy* clock, the two invariable pendulums, and the quadrant (said to have been *Lacaille's*), reported for many years past as being in the possession of the Royal Society.

In consequence of a letter addressed by the Council to Lord Palmerston, Her Majesty's Government, in August 1861, granted the Society 1000*l.* in aid of the proposed temporary maintenance of an Observatory near Poonah, under the superintendence of the late Capt. Jacob. Upon that gentleman's departure for India, in the early part of last year, the sum of 500*l.* of this grant was advanced to him for his necessary expenses. Upon the Council receiving the information of the lamented death of Capt. Jacob, they directed application to be made to Lord Palmerston, for instructions as to the disposal of the balance remaining in their hands, amounting to 500*l.* In answer the Treasurer was requested to repay it to the Treasury, which has been done accordingly.

The Council have awarded the Gold Medal to Prof. Argelander, for his Survey of the Northern Heavens. The President will, in the usual way, explain the grounds of this award.

### *Printed Transactions of the Society.*

The thirty-first volume of *Memoirs* is now published, and contains nine papers. Four of them are communications from Sir Thomas Maclear, referring to Comets which have been observed by him at the Cape of Good Hope, between the years 1853 and 1861. The fifth is by Mr. Cayley, and relates to the Problem of Disturbed Elliptic Motion, the object of the Memoir being to obtain the differential equations for the radius vector, longitude and latitude of the disturbed body, when the last-mentioned two co-ordinates are referred to an arbitrarily varying plane and departure point or origin of longitudes therein.

This is followed by three short papers by Colonel Strange, on certain interesting points connected with the adjustments and construction of Altazimuth Instruments and large Theodolites. These latter investigations may probably be opportune with reference to a considerable number of unusually large theodolites which are now in process of construction for the Great Indian Survey. The volume concludes with a Memoir, entitled "The Results of Planetary and Lunar Observations made at the Madras Observatory between the years 1831 and 1852." The reductions are made by Mr. Breen, after the manner and with the constants adopted at the Royal Observatory at Greenwich. Independently of its intrinsic value, this paper possesses an additional, though melancholy, interest, as associated with the death of Captain Jacob, under whose superintendence many of the observations were made.

## Obituary.

The Society has to regret the loss by death of Prof. Barlow; Dr. Fisher; Thos. Gibbes, Esq.; Capt. Jacob; John Riddle, Esq.; Sir J. C. Ross; J. Walton, Esq., Fellows of the Society; and also of M. Carlini; Professor O. M. Mitchell; M. C. Rümker, Associates. The death of M. Biot, Associate of the Society, was announced in the last Annual Report, but the biographical notice was deferred till the present year.

Peter Barlow, Esq., F.R.S., Member of the Imperial Academy of St. Petersburgh, and of the Royal Academies of Brussels, Utrecht, &c. &c., was born in the parish of St. Simon, Norwich, in Oct. 1776, and died March 1st, 1862, in the eighty-sixth year of his age. In 1801 he was appointed one of the Mathematical Masters of the Royal Military Academy, Woolwich. In 1811 he published his first work, *On the Theory of Numbers;* in 1814, his *Mathematical Dictionary;* and in the same year, his "Mathematical Tables." Up to this time Mr. Barlow's pursuits had reference to abstract science. In 1815 he commenced his first attempt at the application thereof to physical science, founded on experiments on the strength of wood, iron, and other materials. This formed the basis of his work, *On the Strength of Materials*, published in 1817, which, being well received by the architects and civil engineers of the metropolis, led to an intimate acquaintance with the leading professors of those arts. It was also about this time that Mr. Barlow began his connexion with the *Encyclopædia Metropolitana*, to which he largely contributed. About 1819 his mind was turned to the pursuit of magnetic experiments, in which he was very successful, as well in developing the laws of the action of magnetism as in the application of those laws to the correction of a long-standing error in Navigation. These formed the subject of his *Essay on Magnetic Attraction*, pub-

lished in 1819. For this discovery he received several honorary and pecuniary rewards. In 1821 he received the Gold Medal of the Society for the Encouragement of Arts. In 1824, on the adoption of his corrections in the Russian Navy, his services were handsomely acknowledged by the Emperor Alexander. In 1825 he received the Copley Medal of the Royal Society, with pecuniary presents from all the principal Naval Boards.

The subject which had covered him with these honours, and which engaged much of his attention for seven years, having been fully established in the British Navy, as well as in the navies of several foreign powers, and no longer requiring his attention, he turned to optical experiments. In 1827 he suggested a new form of Refracting Telescope, of which he constructed two, and laid them before the Board of Longitude, with a proposition for constructing a large national telescope, which obtained the approbation of that Board. The great difficulty of procuring flint glass for achromatic telescopes seems to have been the principal motive for attempting this novel construction, the basis of which was an object-lens of fluid cased in glass.

Mr. Barlow was a sound mathematician, and was acquainted with the foreign writers at a time when this could not be said of many. He showed this acquaintance in his work on the Theory of Numbers—a subject on which he has, as yet, no English successor. His Tables—which give the squares, cubes, square and cube roots, reciprocals and factors, of all numbers up to 10,000—would have been exceedingly useful to all engaged in practice if the disposition had existed to believe in anything beyond a table of logarithms. As it happened, the use of them was confined to but a few of those whom they might have benefited. The late Mr. Henderson, for instance, who discovered for himself that Crelle's multiplication-table up to 1000 × 1000 is, for many purposes, a far more powerful instrument than the table of logarithms, was a constant user of Barlow's Tables. The work, now out of print, contains many subsidiary matters of use and interest. What is described above, the factors excepted, was republished in stereotype, under the sanction of the Useful Knowledge Society and the superintendence of Mr. Farley, in 1840.

For many years before his death Mr. Barlow had completely relinquished active exertion. Whether we look at his public or his private life, the Society may be proud of his name, which, owing to his great age and long retirement, belongs to a former day.

Capt. William Stephen Jacob, son of the Rev. S. L. Jacob, was born at Woolavington, in Somersetshire, Nov. 19th, 1813. He was chiefly educated at home, until he went as a Cadet to the Hon. East India Company's College at Addiscombe, in the

beginning of the year 1828, being then fourteen years old. Having passed for the Engineers in less than the time allowed for that course of study, he went, according to the regulations then in force, to Chatham, where his aptness as a mathematician still further developed itself. In 1831 he sailed for India, and not long after his arrival at Bombay he was appointed to assist General, then Lieut., Shortrede, who was engaged in the Survey of North-Western India, and in this occupation he was employed for several years.

During his stay in India, Capt. Jacob was not only assiduous in all his professional duties, but found time for his favourite study of astronomy, as evinced by the measures which he made of double stars at Poonah, with his own instruments in his own private observatory.

He came to England on furlough in 1843, and having married during his stay there, he returned to India again in 1845. A few years afterwards he resigned the Company's service, but he continued to reside in India, devoting himself to scientific pursuits, until he was appointed to the post of Astronomer at Madras, without application on his part, but from his several papers transmitted to this Society, and printed in their *Memoirs*. How admirably he discharged his duties there, as a careful and accurate observer, and able computer, is well known to us all, by the orbits which he deduced from his own observations of some binary stars, by his measures of *Saturn* and his satellites, and by his rigorous scrutiny of the mass of *Jupiter*. He found the climate of Madras, however, unsuitable to his health, and after having twice been obliged to return to England on sick certificate, he felt it his duty at last to resign the appointment. In the end of April last year Capt. Jacob, having purchased a telescope of nine inches aperture, returned to India under the auspices of the Astronomical Society, for the purpose of establishing an Observatory on the Mahratta hills. He landed at Bombay on August 8th, and started off for his former place of residence, Poonah; but, having been seized with a violent liver attack, expired there on the 16th of that month, in the 49th year of his age, leaving a widow and eight children.

Capt. Jacob was a man of deep religious feelings, and an earnest Christian. He seemed capable of mastering any subject to which he turned his attention, though mathematical science attracted him the most. His memory was singularly retentive, so that from his extensive reading his mind was remarkably stored with both ancient and modern lore.

Mr. John Riddle was born at Newcastle-upon-Tyne in November 1816, and was the only son of one of the earliest and most respected Fellows of our Society, the late Mr. Edward Riddle.

At the early age of fifteen Mr. J. Riddle was appointed an

Assistant Master in the Greenwich Hospital Schools, and on the retirement of his father in 1851 was chosen to succeed him as Head Master.

In the year 1846 he was elected a Fellow of this Society, and from that time till his death was a regular attendant at its meetings, and an occasional contributor to its papers.

He was appointed, in the year 1854, Examiner in Navigation to the Science and Art Department of the Committee of Council on Education, and held for many years a similar appointment in the Society of Arts. By both these Institutions his services were highly valued.

As a teacher Mr. John Riddle was perhaps unrivalled, and his success in instilling into the minds of mere boys not only the practice but also the theory of Navigation was very remarkable. The influence he possessed with his pupils was unbounded; and the good which he has accomplished by stamping on a vast number of the scientific officers of the Royal Navy the impress of his own vigorous mind so great, that his untimely death can be looked upon in no other light than a national loss.

Mr. Riddle was not only a good mathematician and a successful teacher, but also an accomplished gentleman, with a great taste for poetry and the arts. In society he was a universal favourite, and his urbane manners and intellectual conversation will long be remembered by a large circle of sorrowing friends.

His death was the result of an accident — a fall from a platform in his class-room, which produced concussion of the brain, from which, after lingering sixteen days, he expired on the 11th of October last.

Mr. John Walton was one of the members of the Mathematical Society, and became a Fellow of this Society when, in 1845, the two were amalgamated. He was for many years in business as a sugar-refiner, from which he retired in 1832 with a competency. He joined the Mathematical Society in 1806, and was much respected by the members. He was also a Fellow of the Linnean and Entomological Societies, to whose Transactions he contributed numerous valuable papers. He died at Knaresborough on the 3d of January, 1863, aged 78.

Jean-Baptiste Biot (born April 21, 1774, died Feb. 3, 1862) is the last of the great men of science who belonged to what he himself jocosely called the *first edition* of the French Revolution. To give any account of his labours on such an occasion as the present would be inadmissible: several of them are too well known, the others are too numerous. We shall therefore allude to but few of the 477 heads under which his writings have been enumerated by M. Lefort, the son of his

daughter's daughter, who declares himself certain that the list is far from complete.

The father of J. B. Biot, whose ancestors had been farmers in Lorraine, was himself in some office of the Treasury. The son, after studying at the Collège Louis-le-Grand, joined the army as a volunteer, and was present at the battle of Hondschoote, in 1793. He then retired from military life, and became a student in the Ecole des Ponts et Chaussées, and in the Polytechnic School. In 1797 he was named Professor of Mathematics at the Central School of the department of the Oise. He here introduced himself to notice by some mathematical papers, and became known to Laplace. In 1800 he was removed to Paris, as Professor of Mathematical Physics at the Collège de France, and Associate of the Institute. At his death he was a member of three of the four French Academies—a distinction which few, if any, ever gained before him. In 1806 he commenced, in concert with Arago, his continuation of the arc of the meridian. In 1808 he measured the length of the pendulum at Bordeaux. In 1817 he repeated this operation in Scotland and the Shetland Islands. In 1818 he was employed at Dunkirk, in concert with an English Commission, on the determination of the latitude. In 1824 and 1825 he was employed in Illyria, &c. on the measurement of the pendulum at different points of the mean parallel of latitude, and also at the extremity of the Spanish arc. These were the points in which a long life passed in physical investigation was most connected with astronomy. It is not necessary to speak in detail of the publications connected with the Great Survey. His work, entitled *Traité Elémentaire d'Astronomie Physique*, of which three editions were published (1805, 1810–11, 1841–57) was more than its name imports, being a mathematical system, in which the mathematical part is subordinated to a very extensive treatise on astronomy strictly physical: it is, in fact, what was left undone in the closely mathematical system of Délambre.

It is not our business to do more than refer to the extensive writings of Biot on optics and physics in general. All of middle age who were students of these subjects will remember that Biot was the originator of those encyclopædic works on experimental science which continue to appear from time to time. Four valuable volumes, the *Traité de Physique*, appeared in 1816; followed, in 1817, by the *Précis Elémentaire*, in two volumes. The reader of these volumes remembers how frequently Biot had to refer to his own experiments, and how completely he was made to feel that his instructor had travelled over all the ground, either by experiments of his own making, or actual and personal cognizance of those made by others. In these, as in all his other publications, there is continual evidence of the presence of the mathematician who has all the powers of geometry in reserve, but is prevented,

both by a natural turn for the experimental and by the matured habits of an old teacher, from introducing more than will just serve the purpose.

Biot must be numbered among the historians of science. Not that he ever wrote a work professedly on history, but because his writings on historical points form a large mass, involving much research and much valuable criticism. On the ancient Egyptian and Oriental astronomy he was engaged during most years of the second half of his life. In particular we may refer to his "Recherches sur l'Année vague des Egyptiens," read before the Academy of Sciences, 1831, where he shows, from the hieroglyphics in the Rhamesseum, at Thebes, that the point of the vernal Equinox was in the constellation *Taurus* during the reign of Rhameses III. He was editor of the *Journal des Savans* in 1816, and remained a contributor to the end of his life. He wrote in it, or in the *Moniteur Universel*, about 120 articles, many relating to the history of the past, and all of the critical cast. Thus we have, from 1816 to 1862, a succession of descriptive accounts, involving history or criticism from one mind. To this must be added twenty-three biographies in the *Biographie Universelle*, many of which are cited as separate works, and many short articles scattered elsewhere.

An account of the opinions of Biot, as involved in his accounts of others, would lead to discussions involving matters of controversy. The style in which he treats his subjects is eminently attractive. In his didactic writings he is diffuse, and his own peculiar spirit is undiscernible through his explanations. In his critical writings he has a strong and distinct character, marked by satire powerfully applied, but without ill-nature. In his private life he gained the respect of all. He was the Nestor of the Institute for many years. He was for three weeks the subject of Louis XV., and lived nearly ten years under Louis Napoleon. Of this long life, sixty-five years were passed in public posts.

Francisco Carlini, Director of the Royal Observatory of Milan, died at Milan on the 29th of August, 1862, in his seventy-seventh year.

He commenced his astronomical career at an early period, by the calculation of the *Milan Ephemeris* for the year 1804, and his highly useful labours extended over two-thirds of a century. During the whole of this period he prosecuted his studies for the advancement of science with unceasing assiduity.

He continued his calculations and writings in the *Milan Ephemeris* until his last illness, and only four weeks before his death he completed his calculations of the Elements of the second Comet of 1862.

Carlini's writings and his exertions for the advancement of

learning and science are familiar to all astronomers. He was conversant with foreign languages and literature, and spent much time on works of mechanism. His deportment was pleasing and agreeable, and his moral character blameless.

Of our late valued Associate, Professor Ormsby Macnight Mitchel, it may be said the account of his life resembles a romance rather than a biography. He was one of those many salient instances of unconventional humanity who present themselves in a new country for the instruction, if not for the imitation, of their contemporaries. America may be justly proud both of the intellectual powers and the versatility of a man who, in early manhood, was a Soldier, then a Professor of Mathematics, then a Lawyer, then an Astronomer, then a Railway Engineer, and finally as a Major-General, ended his life, as he began it, in the Army.

Professor Mitchel was born on the 28th of August, 1810, in Union County, Kentucky. At an early age he gave promise of the ability and eminence which his future so fully realised. He was appointed a Cadet in the U. S. Military Academy in 1825. He graduated with distinction in 1829, and was very soon appointed Assistant Professor of Mathematics, which post he held for two years. He subsequently resigned his commission in the Army, and, after practising Law for a short time, he accepted the chair of Mathematics and Astronomy in the Cincinnati College, Ohio, in which position he continued for ten years.

It was here that he commenced a series of lectures; and those which he delivered on the physical constitution and telescopic appearances of the planets created so vast an enthusiasm, that it was resolved to furnish the city with a large telescope forthwith. Subscriptions for this purpose poured in from all quarters; and as specie was not always at hand, there were not a few contributions in kind, such as hats and caps, and other unastronomical apparatus. Mitchel then proceeded to England in quest of his telescope, and was there introduced to the Astronomer Royal by John Quincy Adams. At his earnest request, Mr. Airy allowed him to go through the greater part of the Greenwich course; and for some time he worked as a computer at one of the Royal Observatory desks. On his return home, the population of Cincinnati assembled, in the largest church of the place, to hear the account of his mission. The first-fruits of Mitchel's labours with his large equatoreal was the discovery of the companion of *Antares*. But, inasmuch as a rival telescope at another place, owing to an idiosyncracy of its object-glass, showed two companions instead of one, the ill-fated Astronomer and his Observatory were shorn of their glory and their subscriptions besides. After this, the Professor was concerned as Projector, Director, and Engineer, in "building" certain Railways; and it is hoped

he realised a good fortune thereby. He was in England a second time for the sale of railway bonds.

During his career as an Astronomer he was certainly one among the first who in any way applied galvanic electricity to astronomical observations; but this remark is not intended to apply to the principle of the *chronographic* record.

In the course of the unhappy struggle now, alas! consuming the resources and the population of a magnificent country, Mitchel returned to the Army, and, at the age of fifty-two, after a brief illness of four days, died of fever at Beaufort, being at that time a Major-General and Commander of the Federal Army in South Carolina.

## Proceedings at Various Observatories.

### *Royal Observatory, Greenwich.*

In the ordinary operations of the Royal Observatory, Greenwich, no changes of importance have been introduced during the past year; the observations have been of the usual character, and the reductions have not been allowed to fall behind.

The Star Observations from 1854 to 1860 are being incorporated into a Catalogue: this will contain about 2020 stars; star constants, precessions, and secular variations have been recomputed for all the stars. The work is now far advanced and will shortly be ready for the press.

The difference in longitude between the Royal Observatory, Greenwich, and Knightstown, Island of Valentia, has been redetermined. The very unfavourable weather of the past season protracted this operation much beyond the expected limits, and it has pressed heavily on the Observatory; the result obtained is, however, satisfactory; it agrees almost identically with the chronometrical determination of 1844. Advantage has been taken of the favourable circumstances connected with the late opposition of *Mars;* differences in Right Ascension between *Mars,* and stars east and west of the meridian, have been obtained with the Great Equatoreal. These observations are now under reduction, and it is hoped that the result may be laid before the Society at its next Meeting. *Mars* has been well observed on the meridian for combination with the Declination observations of the Southern Observatories. The method for determining the motion of the Solar System in space, proposed by the Astronomer Royal in 1859, has been applied to 1167 stars. The reductions are completed, and the results will shortly be laid before the Society.

The apparatus arranged by the Astronomer Royal for observing the fixed lines of Star spectra, and referring them to the fixed lines of the Sun spectrum, has been completed; the

arrangement is quite successful: pressure of other work has, however, prevented any systematic employment of this apparatus up to the present time.

### *Royal Observatory, Edinburgh.*

From the Royal Observatory, Edinburgh, we hear of the usual round of official duties performed. The first and most prominent of these consists of the double system of time-signals, the visible and the audible, which are kept up daily from the two chief hills of the city, under the electric control of the Observatory and the interested surveillance of the citizens, but with a decided bias in favour of the "gun" over the "ball." Both methods have, however, at the present moment received a sudden check from the indirect effects of a most anomalous storm of lightning, which broke over the city with almost a hurricane of west wind and sleet on the 4th of February, at 7 P.M. The lightning, which is described as vividly blue and green, was seen to dart more horizontally than vertically, and at last set fire to the lower part of Nelson's Monument, an important intermediary in supporting the Observatory electric wires to both the time-ball and time-gun. The striking of a tall building so low down as in this case, or one-seventh from the bottom, is evidently noteworthy, together with the intensity of the discharge, which pierced holes of three quarters of an inch in diameter through a leaden roof, streaming at the time with conducting water, and furnished with metal pipes; but the most immediately important matter in regard to the time-signals has proved to be, that every member of one whole bundle of so-called "permanent" magnets in the controlled clock at the Castle has had its poles changed; and some similar bars in a clock at the Observatory has had two or three pairs of poles put into them.

Another, and a more considerable employment of the time and labour of the Observatory, is that required for the reduction of the meteorological observations taken by observers of the Meteorological Society of Scotland at fifty-five different stations in the country; and furnished, partly every month and partly every quarter, to the Registrar-General of Births, Deaths, and Marriages, in whose returns they are duly printed.

The Board of Visitors of the Observatory having desired that the original observations of the Teneriffe experiment should appear,—the printed volume of the *Edinburgh Astronomical Observations* has been detained for the insertion of a Teneriffe Appendix, which is now reported complete within a page or two. The same Board has also made some attempts during the past year to free the position of the Edinburgh Astronomer from the very untoward anomaly of being a public office without any salary attached to it, the actual condition in

which recent reforms at the College have left that of the Astronomers-Royal of Scotland. But up to the present time the Board has not succeeded in making any advance either in this point, or in that which they took up last year, viz., securing for the Astronomer a residence in or near the Observatory, instead of at the impracticable distance where it is now found.

### *Royal Observatory, Cape of Good Hope.*

True to the chief object of its foundation, the Royal Observatory at the Cape of Good Hope has been occupied during the past summer by the parallax observations on *Mars*. These would have been made without doubt, whether any particular series of corresponding ones in Europe had been announced or not; and, in fact, they were made even in face of the statement contained in our *Monthly Notice* of May, which arrived at the Cape on the 15th of July, to the effect that the series of *Mars*-opposition observations prepared by a great Northern Observatory, would only be attempted if a promise of co-operation from a Southern Observatory should arrive on or before the 20th of August; and Sir Thomas Maclear knew only too well, that, though he answered by return mail, his letter could not reach Europe sooner than the 30th or 31st of August.

The Cape observations, nevertheless, began punctually on the 20th, and were continued on from that date through the whole opposition period, up to November 3d, weather permitting, with the result of measures being obtained on 45 nights out of 75. These measures were taken on the meridian with the fine transit circle of iron; others had been attempted on Mr. Airy's suggestion for the parallax in Right Ascension, with the equatoreal; but these were completely defeated by the badness of atmospheric definition when the planet was at a very low altitude, for there was nothing indicative of a "limb" to be seen about it. "I exceedingly regret the failure," writes Sir T. Maclear; "partly because the method was recommended by Mr. Airy, and partly because the advantage of the method is undeniable if a clear sky and good definition could be commanded at low altitudes. Unfortunately, atmospheric phenomena decline to be at the beck and call of practical astronomy." A most true remark, we may observe, unless the subject be treated in the manner adopted by Mahomet and the mountain; and by precisely the same act, too, viz., going to a mountain, and ascending there so high, that both observer and telescope shall find themselves in what Sir Isaac Newton describes as the serene and quiet (and necessarily rarified) air, above the grosser clouds, and which as he long ago assured astronomers is "the only remedy by which that *confusion of rays which arises from the tremours of the atmosphere*," can ever be removed from large telescopes.

### *The Radcliffe Observatory, Oxford.*

No material change has occurred in the organisation of the Radcliffe Observatory, Oxford, since the publication of the last Annual Report of the Society. The staff of Assistants is precisely the same as at that time, and the subjects of observation have been those indicated in that Report,—namely, for Meridian observations, stars between the fifth and seventh magnitudes, and the Sun, the Moon, and the large planets, including a good series of observations of *Mars* near opposition. In addition, *Mars* has been well measured with the heliometer, and the results have been given to the Society in a Memoir by Mr. Main. *Saturn* has also been measured during the disappearance of the ring, and the resulting ellipticity agrees very closely with the former value deduced at Greenwich. The Great Comet of 1862 was observed on several evenings, and the results have been communicated to the Society. The number of double stars which have been observed with the heliometer now exceeds two hundred; but the past year has been singularly unfavourable to all classes of delicate observations.

The Carrington Transit-circle has been used throughout the year 1862 without interruption, and the results will, it is hoped, sustain the high character which it had while in the hands of Mr. Carrington.

The Photographic Meteorology has been kept up without intermission, and, in the hands of Mr. Lucas, the photographs are much better and the interruptions of continuity less than in former years.

The reductions of the observations are in a tolerably satisfactory state. The twentieth volume of the Radcliffe Series, containing the observations for 1859 and 1860, was published in July last, and the twenty-first volume is now being printed with great rapidity, the reductions of the astronomical observations for 1861 being nearly completed. The reductions of the observations for 1862 are also in progress.

Considering the smallness of the force employed, consisting of the Director, two Assistants, and one Computer, the amount of work which has been accomplished during the preceding year is highly satisfactory; and, without any further encroachment on the resources of the Trustees, a few years of such continuous labour must produce results of very great importance to astronomy.

### *The Cambridge Observatory.*

The meridian observations made at this Observatory, under the direction of Prof. Adams, during the past year comprise, in addition to those of the fundamental stars, Observations of the Stars which were used for comparison with Comet II., 1861,

Observations of the Sun near the summer and winter Solstices and the autumnal Equinox, Observations of the planets *Jupiter* and *Neptune*, and Circle Observations of *Mars*, and of the stars selected by Dr. Winnecke to be compared with the Planet in Declination, with a view to the determination of its parallax.

The Equatoreal Observations comprise a series of observations of Comet II., 1862, and a series of comparisons in R.A. between *Mars* and neighbouring stars, taken on both sides of the meridian according to the plan described by the Astronomer Royal in the *Monthly Notices*, vol. xviii. p. 277. By this method the parallax of *Mars* may be determined by means of observations taken at a single Observatory. Charts drawn on a large scale were prepared of all the stars near the path of *Mars*, which are contained in Dr. Argelander's valuable Survey of the Northern Heavens, and the stars of comparison were selected from these. The weather was in general very unfavourable during the course of these observations, so that not many sets of corresponding evening and morning observations could be obtained.

Some new arrangements have been made in connexion with some of the instruments. The old lever counterpoises of the Transit Instrument were removed some years since by Professor Challis, and replaced by spring counterpoises, in order to allow the use of micrometer microscopes, adjusted for viewing dots placed on the ends of the pivots, so as to afford the means of eliminating any errors arising from the form of the pivots. The spring counterpoises, however, have been found to act in a very unsatisfactory manner, as the pressures which they exert are continually varying with changes of temperature. Prof. Adams has accordingly removed them and restored the lever counterpoises, introducing, however, such an alteration into their arrangement, that the apparatus for examining the forms of the pivots may now be used while the counterpoises are in action.

The pendulum of the Transit Clock, which was in an unsatisfactory state, has been put into good order by Mr. Frodsham.

In consequence of the varying length and weight of the declination rods of the Northumberland Equatoreal, corresponding to different North Polar Distances, it is impossible to balance the instrument by any system of permanent counterpoises. A series of adjustible weights has therefore been introduced, which may be very conveniently applied, and by means of which, for any given value of North Polar Distance, the instrument may be very nearly balanced in all positions. Since these weights have been in use, the performance of the driving clock has been far more satisfactory than it was before.

The Jones Equatoreal has been dismounted for the purpose of being examined. Several of the springs which relieve the pressure on the lower pivot were found to be broken, and

the microscopes were out of order. The instrument is now in the course of being put into working order by Mr. Simms.

The dome of this Equatoreal was only moved, with difficulty, by the united force of two persons, and thus the use of the instrument was rendered exceedingly inconvenient. This dome is supported on fifteen cast iron wheels, which run in channels, above and below, also of cast iron. These wheels were formerly in bearing along their whole breadth, which is considerable, and thus a large amount of sliding friction was called into play when the dome was moved. The wheels have now been turned so that the breadth of the bearing surface is very much reduced, and the result is that the dome can be easily moved by one person. Surrounding the dome is some ornamental work, supported by a rim of cast iron, which was formerly embedded in the stone wall. Of course the alternate expansion and contraction of the iron from heat and cold, split the stone-work, and thus allowed damp to be admitted into the wall; an arrangement is now made which permits the free expansion and contraction of the iron rim, and which also effectually secures the wall against damp.

Some progress has been made in the arrangement and classification of the detached Memoirs and Pamphlets belonging to the Library of the Observatory, with a view to their being bound up in volumes. Professor Challis is proceeding with the printing of Vol. XX. of the Observations, which will include the remainder of the Meridian Observations to the end of 1860.

### *Liverpool Observatory.*

At the Liverpool Observatory, Mr. Hartnup has been recently engaged in discussing the sea-rates of nearly two thousand chronometers, for the purpose of ascertaining the average errors for voyages of different lengths. On comparing the rates at sea with the rates of the same chronometers obtained at the Observatory, the importance of attending to the thermal correction has manifested itself more strongly than ever; and, in addition to this, the rates are often found to increase or diminish with such regularity from one month to another, that a correction for this may also be very frequently applied with great advantage. Mr. Hartnup has, therefore, been induced to make considerable alterations in his method of testing and giving the rates of chronometers, with the view of ascertaining the value of these corrections more accurately, and of rendering the application of them more simple.

### *Glasgow Observatory.*

At the Glasgow Observatory Professor Grant continues to employ the Meridian-circle in the observation of a selection of stars, chiefly below the fifth magnitude. Much of his time

during the past year has been occupied with proceedings having for their object to increase the instrumental efficiency of the establishment. The want of an instrument for making extra-meridional observations has been much felt, but this defect is in the course of being remedied by the erection of the equato-really-mounted refractor of nine inches aperture, which belonged to the late Sir William Keith Murray, of Ochtertyre, and has been recently purchased by the University. For this valuable accession to the resources of the Observatory, the University is indebted to a few gentlemen chiefly residing in Glasgow, who have most liberally supplied the funds, not only for the purchase of the instrument, but also for the building of a separate edifice for its reception. It is expected that the instrument will be in complete working order before the close of this month.

### *Mr. De La Rue's Observatory.*

The Cranford Observatory during the past year has been devoted mainly to photographing the Sun's disk, by means of the Kew heliograph, which has been placed there for that purpose. Mr. De La Rue's assistant, Mr. Reynolds, has obtained during the period from Feb. 7th, 1862, to Feb. 7th, 1863, about 160 photographs, one at least having been taken on every day when the state of the weather permitted. Thus a series, as continuous as possible, and extending over a whole year, has been procured, and the pictures will hereafter be measured by means of the micrometer, and the resulting data carefully discussed.

Besides photographs of the Sun, several fine lunar photographs have been taken of phases not included among the negatives previously obtained; and experiments in enlarging some of the lunar photographs to the dimensions of Messrs. Beer and Mädler's map have resulted in the production of charts of great utility and beauty. Messrs. Smith, Beck, and Beck, contemplate publishing these large charts in their entirety, for the use of selenographers; and also portions of them, suitable for the special study of those who may wish to devote themselves to the delineation of the minuter details, with the aid of eye-observations.

By the combined efforts of amateurs it is to be expected that the surface of the Moon will, in this way, be depicted with an accuracy and minuteness hitherto unattainable.

It will be recollected that Professor Selwyn, of Ely, who also has been working with an instrument constructed on the model of the Kew heliograph, but of smaller dimensions, has procured sun-pictures, on two of which, namely, on those procured respectively on Aug. 4th and Oct. 1st, he observes a notch in the Sun's limb corresponding in position with certain large spots; while eye-observations revealed a streak of the Sun's limb exterior to the supposed gap. This streak of the Sun's

photosphere is depicted on Mr. De La Rue's photographs, and the photographic and eye-observations are thus shown to be in accordance.

During the past year Mr. De La Rue's paper On the Total Solar Eclipse of 1860 has been published in the *Philosophical Transactions* of the Royal Society, and the applicability of astronomical photography to the obtaining of numerical data may be considered as having been therein clearly established.

### *Hartwell Observatory.*

Little can be said respecting the proceedings at the Hartwell Observatory during the last year. Since the unexpected departure of Mr. Pogson, the regular work has been discontinued; but it is to be hoped that the Catalogue of Variable Stars commenced at Hartwell, and now in progress at Madras, will with time be completed.

Meanwhile, there is what may be termed a continuous task to be carried on at the Observatory by the Assistant, Mr. Samuel Horton, under the direction of Admiral Smyth,—namely, the examining and remeasuring of 145 Double Stars, selected from the Cycle of Celestial Objects.

### *Hopewell Observatory, Haddenham.*

Mr. Dawes, owing to a combination of bad weather and bad health, has been able to make but few astronomical observations; but among them are some of especial interest. The transit of the shadow of the brightest satellite of *Saturn*, *Titan*, across the disk of the planet, has been observed; and to this may be added one observation of an eclipse of *Titan* itself in the planet's shadow. The former is a very rare phenomenon, and Mr. Dawes considers the latter to be unique. Sketches also have been made of the physical appearances of *Mars*, of Tuttle's Comet, and of certain solar spots.

It will be remembered that during the course of the present year, the late Captain Jacob, under the auspices of our Society, left England, with a telescope of adequate dimensions and of great excellence, for the purpose of observing some of the heavenly bodies at a highly favourable station in the Bombay Presidency. It is with very deep regret that the Council record the termination of this expedition and the disappointment of their well-founded hopes, caused by the untimely death of the able observer at the very moment of the commencement of his arduous work. The cost of the expedition has been defrayed partly from funds provided by the liberality of the British Government, and partly from the private resources of the lamented astronomer himself.

## The Progress of Astronomy.

The Council are much gratified in being able to report that astronomical science during the past year has advanced with a steady and interesting progress. In the first place they invite the attention of the Society to the publication by Mr. De La Rue of a group of solar spots, printed in an ordinary press, from a metallic block, procured by the sole agencies of light and electricity, and untouched by any tool. This is the first instance of the application of Mr. Paul Pretsch's phototype process to the delineation of any celestial object. A second example of this important process has been given by Mr. De La Rue in his recently published Bakerian Lecture on the great Solar Eclipse of 1860. It is obvious that great will be the gain, if by the aid of this process, or by any other means, it shall ultimately become possible to multiply reliable copies of the delineations of celestial phenomena, from which have been eliminated uncontrollable errors, arising either from the imagination of the observer or from the imperfect art of the engraver.

But the successful application of photography has not been confined solely to the delineation of the physical features of celestial objects; in the hands of Mr. De La Rue it has vied in accuracy of measurement with the micrometer as ordinarily employed. As one instance of this out of many others, it may be mentioned, that at the middle of the totality of the great Solar Eclipse of 1860, the moon's diameter as obtained from the photograph was 1986″·2, while that inferred from calculation was 1986″·1.

In the next place Professor Bond's Monograph on Donati's Comet is entitled to especial commendation. Owing to the great pains, expense, and skill bestowed upon the numerous and elaborate engravings, this memoir can scarcely fail henceforth to raise the standard of excellence in astronomical illustration. A copy of Mr. Bond's work has been presented to the Society, and will probably be esteemed by the members as one of the most valuable presents of the year.

The hypothesis by which Bessel first attempted to explain the cause of the irregularities in the Proper Motions of *Sirius* and *Procyon* has received confirmation in an important degree from the recent researches of Mr. Safford of Harvard College and Mr. Auwers of Königsberg. It now appears established as an astronomical fact, that the heretofore anomalous motions of *Sirius* and *Procyon*, both in Right Ascension and in Declination, are explained and satisfied by the existence of invisible masses, round which these stars may be conceived to revolve, *Sirius* in fifty, and *Procyon* in forty years. The nature and amount of the substantial advance thus made in a most interesting but difficult branch of stellar astronomy, may be appreciated from the following philosophical remarks of Pro-

fessor Bond, to which both the Astronomer Royal and Sir John Herschel have added the expression of their general concurrence. "It is conceivable that the outstanding discrepancies from the hypothesis of a uniform motion in either Right Ascension or Declination, each series being taken by itself, might follow a systematic law which has yet nothing whatever to do with an actual change in the motion of the star, being merely an expression of the relations between errors of the determined places; and in fact Bessel's hypothesis of an invisible companion has always been open to suspicion on this ground. Now, however, the evidence excludes this suspicion, since it is in the highest degree improbable that the same law of error should hold for the discrepancies in Declination and for those in Right Ascension as well. All reasonable objection is thus removed, and the presence of an invisible mass in the neighbourhood of *Sirius*, comparable in magnitude with it, is entitled to be received as an established fact in astronomy."

In connexion with this subject it is worthy of remark that, as in the case of *Neptune*, the place of a visible celestial object was first indicated by the results of calculation; so, in the case of *Sirius* and *Procyon*, the presence of invisible masses is first felt through the agency of telescopic observation.

Among other subjects which demand our notice are two inequalities in the periodic time of Halley's Comet, discovered by M. Angström of Upsal; what is most observable in relation to this discovery is the fact of its having been deduced from data which were within the reach of all astronomers. An abstract of this short memoir appeared in our January number; a mere inspection of the plate appended to the original paper in the *Upsal Transactions*, will be sufficient for the appreciation of M. Angström's method, and of the conclusion which he derives from its application.

Practical astronomers will no doubt watch with interest the development of the properties of the new metallic alloy named Aluminium Bronze, under the hope that it may be found to possess some properties which render it a valuable substitute for gun-metal or brass in the construction of astronomical instruments. Colonel Strange has laid the results of his careful and able study of this compound so recently before the Society, that much further remark is here unnecessary. It may, however, be a matter of interest to add that in the framing of the large theodolites for the Indian Survey, Messrs. Simms have constructed some of the smaller portion with this alloy; with a laudable caution they await the results of further experience in the casting of this new substance, before they employ it to a more considerable extent.

The Society, and indeed all persons interested in the progress of physical science, will be glad to hear that the Astronomer Royal has completed an apparatus wherewith, in conjunction with the great Equatoreal at Greenwich, it is intended

to observe the dark lines in the spectra of stars. Some of these spectra have already been carefully observed and recorded by Donati; but owing to the brilliant speculations and remarkable experiments of Messrs. Kirschoff and Bunsen, there are at this moment so many questions of surpassing interest, connecting these lines with the nature of light in general, and with the physical constitution of the Sun in particular, that it is a matter for congratulation to know that the subject is also taken up by a philosopher so peculiarly competent for its investigation.

The Society will learn with much interest that Mr. De La Rue has enlarged some new photographs of the surface of the Moon in her various phases, to precisely the same scale as that adopted in Messrs. Beer and Mädler's map. It is needless to dilate on the peculiar value of such reliable delineations.

Glass mirrors of very considerable dimensions, and silvered by a chemical process, are now manufactured in Paris by Messrs. Secretan, and in Munich by Professor Steinheil, at a comparatively moderate cost. The advantages, however, which arise from the material employed, are to some extent counterbalanced by the necessity of a renewal of the silvering more frequently than a metallic speculum requires to be repolished.

Mr. Carrington has completed his Memoir containing observations during seven years and a half of the Solar Spots, and has taken preliminary steps for securing its publication. The amount of illustration indispensable to the subject has proved an impediment to its appearing in the *Transactions* of a Society whose issue is large; and it is probable that it will ultimately be undertaken by a publisher as an independent work on a subsidy of a certain amount being guaranteed. The Memoir consists of two parts, text and plates. The text contains, firstly, a preface describing fully the processes of observation and reduction, and the theory of certain small corrections not taken into account, and is followed by the auxiliary tables used at Redhill. The second section consists of a catalogue of all the nuclei which were selected as primary points of observation, arranged in columns, which need not be detailed on this occasion. The third section consists of a discussion of the deduced heliographical position of those nuclei in each group which, by aid of the diagrams, are identified as comparable on different days, and especially with the view of deducing the diurnal motions of the nuclei in both elements, which result from the use of very approximate elements of the rotation. In the next section these residual motions are assembled in a table arranged in order of the latitudes of the nuclei discussed, and the law which holds good in the mean is deduced with full evidence of the process pursued. The conclusion arrived at has already been stated to the Society at the Meeting in June last. The fifth section treats of the corrections of the assumed position of the solar equator, the theory and data being fully given. The re-

mainder of the text need not be particularly described. The plates are about 170 in number; two containing the figures necessary for explaining the method of observation and reduction; then ninety-nine plates, each showing the groups recorded during one whole rotation; then three, in which the distribution in latitude is rendered self-evident by compression; and, lastly, a series of plates necessary to supplement the rotation-plates, on which one aspect of a group can alone be shown. On these latter every appearance of a group is given, ranged in a series of squares from the top to the bottom of the plate, and thus the record is rendered complete, condensed as far as possible, and immediately instructive to the eye. No disks are given. During the past summer, Dr. Sabler, of Wilna, visited this country, to inform himself of the process of photographic registration organised by Mr. De La Rue, and was willingly allowed to copy the tables and extract all such portions of the last-mentioned Memoir, which he desired to have for use at the Observatory which the Russian Government has devoted to this branch of astronomy.

Some addition has been made to our more accurate acquaintance with the Moon's surface by the zealous and minute observations of Mr. Birt, who, during several years, has devoted much of his attention to this branch of astronomy. Mr. Birt is now examining the regions around *Plato*, under the hope of extending the discoveries made by Beer and Mädler.

Captain Shea continues with much perseverance to observe the number and position of such solar spots as are within the limits of vision of a small telescope. His delineation of the Sun's disk would be incomparably more valuable if they contained a fiducial line, or some definite co-ordinates of reference. Captain Shea's observations have now extended over a period of fifteen years, and four volumes of the results have been presented to the Society.

### *Planet Mars.*

The planet *Mars*, during the last opposition, has been closely scrutinized by several astronomers, with instruments well adapted to such observations. The general result of these observations tends to show that the principal details visible on the surface of the planet remain constant during a long series of years. The snow or ice regions in the vicinity of the poles, however, are found to undergo changes not attributable to the effects of perspective arising from the changed position of *Mars'* axis in relation to the observer. Our energetic member, Mr. Lockyer, has succeeded in making a series of beautiful drawings of *Mars*, as seen in his 6-inch refractor, by Cook. Professor Phillips, of Oxford, has also made a

similar series, with the aid of an instrument of the same dimensions; and Father Secchi, of Rome, has also produced a very extensive series, so that materials now exist for the production of a very accurate globe of this planet.

### *Minor Planets.*

Since the last Anniversary the number of Minor Planets has been increased from seventy-one to seventy-seven. In the middle of February it was announced by Professor Bond, that Mr. Safford, upon discussing a series of observations by Dr. Peters, presumed to belong to *Maia*, had found that only three of them could be reconciled with the observations of that planet at Cambridge, U.S., and had shown Dr. Peters' observations to apply to a previously unknown member of this group: it has since received the name *Feronia*. The *seventy-third* minor planet was detected by Mr. Tuttle, at Harvard College Observatory, U.S., on April 7, and has been named *Clytie;* the *seventy-fourth*, called *Galatea* on the proposition of Professor Littröw, was discovered by Mr. Tempel, at Marseilles, on August 29; the *seventy-fifth* by Dr. Peters, at the observatory of Hamilton College, N.Y., on September 22, and is yet unnamed; the *seventy-sixth* by Professor d'Arrest, at Copenhagen, on October 21, for which he has proposed the name *Freia;* and the *seventy-seventh* by Dr. Peters, on Nov. 12. A planet was detected by Dr. Luther, at the Observatory of Bilk, near Dusseldorf, on August 31, and has since proved to be *Daphne*, which had not been found at several previous oppositions, and indeed may be said to have been nearly lost.

### *Comets.*

The Cometary discoveries of the year are *four* in number; the *first* Comet was found by Mr. Schmidt, at the Observatory of Athens on the evening of July 2, and two hours later by Mr. Tempel, at Marseilles; a parabola suffices for the representation of the observations. The *second* appears to have been seen at Marathon, U. S., by an amateur astronomer, Mr. Swift, as early as July 15; three days afterwards it was found by Mr. Tuttle, at Harvard College, Massachusetts, and on the 22d was perceived at the Observatory of the Museum at Florence, by Mr. Toussant: other independent European discoveries have been recorded. This Comet was for some time a conspicuous object to the naked eye, and exhibited many interesting physical phenomena. It was observed in Europe till near the end of September. Observations taken by Mr. Tebbutt and others in Australia have also been published. The orbit is certainly elliptical, and, according to

a careful discussion by Mr. Oppolzer of the Vienna Observatory, it would appear that the time of revolution is about 142 years. Computations by other astronomers sufficiently confirm this result. The *third* Comet was detected, on the morning of November 28, by Professor Respighi, at Bologna, and three days later by Dr. Bruhns, at Leipsic. It is still within reach of powerful instruments. The orbit does not sensibly differ from a parabola, so far as can be judged from calculations up to this time. The *fourth* Comet, discovered by Dr. Bruhns on the morning of December 2, was not observed in Europe after the middle of the month, on account of its rapid motion towards the south. A fortnight's observations are well satisfied by a parabolic orbit.

The short-period Comet of Brorsen has passed its perihelion unobserved, chiefly owing, no doubt, to its unfavourable position in the morning twilight.

The Council in their Report of the astronomical proceedings of the year cannot but advert to the recent perilous balloon ascents of their colleague, Mr. Glaisher, to heights above the earth's surface heretofore unreached. One of the main objects of these ascents was to extend and improve our knowledge of the relation which exist between increase of elevation and the corresponding variations of temperature and moisture, these variations in their turn having an intimate bearing on the theoretic determination of atmospheric refraction.

The results of Mr. Glaisher's observations indicate that the hypothesis of a diminution of 1° Fahr. of temperature for every additional 300 feet of elevation must be abandoned, even for inconsiderable heights above the earth's surface. The variation of temperature for the same variation of altitude is found also greatly to depend on the clearness or cloudiness of the sky. Thus, through the first 1000 feet, under a cloudy sky there is a change of 1° Fahr. for every 213 feet, but if the sky be clear there is a diminution of 1° Fahr. for every 139 feet. At extreme heights, such as between 25,000 and 30,000 feet, it requires a full 1000 feet of additional altitude to cause a diminution of temperature of 1° Fahr.

In conclusion, the Council have to report that among the subjects which have engaged their attention during the year, the promotion of the Survey of the Southern Hemisphere, on the plan of Dr. Argelander, has had special consideration. A committee, consisting of the Astronomer Royal, Mr. Hind, and Mr. Carrington, was appointed to confer on the subject, and finally handed in the following report at the first meeting of this year, which the Council have unanimously adopted, and ordered to be printed as part of the Annual Report of this day.

"1. The proposal which was submitted to the Council in the month of June was principally based on the expressed wish of Dr. Argelander that a Survey of the Southern Hemisphere of Stars should be undertaken by British means on a similar scale to that which he had in hand at Bonn; and the proposition has been renewed, of late years, frequently in his private correspondence, as he was approaching the termination of his undertaking. The Committee fully agree with his feeling that it is highly desirable, for the progress of Astronomy, that such a Survey of the Southern half of the Heavens should be made, and that the ideal of the two halves of the Survey, being contemporaneous, should not be departed from more than may be unavoidable. The Committee believe that the promotion of undertakings such as the present lies fully within the scope of action of the Society, as defined by its By-laws; and they think that the Council may usefully take into consideration, at the present time, whether advantage may be taken of one of the stations which the country possesses in the Southern Hemisphere — as at the Cape of Good Hope, Sydney, Williamstown, Melbourne, or Hobarton.

"2. The work involved in the proposed Survey is of very simple character, but of considerable extent. The number of stars to be observed may be estimated at about 300,000, each to be twice recorded, without reckoning the revision of imperfect zones, and searches for the purpose of removing doubtful cases. By the employment of four persons simultaneously, the work of observation, reduction, formation of standard catalogue, collation with previous authorities, and formation of maps, would, as for the Northern half, under equally efficient superintendence, necessarily require the labour of from six to eight years — an estimate which, admitting of little correction, forbids the entertainment of the supposition that there is any probability of the task being at any time executed by private enterprise. The work is essentially one which must be performed by the staff of an official observatory, or by some special addition to the fixed staff of an establishment; and this being the case, the support of a body such as the Royal Astronomical Society, and the assistance of external funds, appear the only available means of carrying out a work of the kind contemplated.

"3. Should the Council take this view of the matter, the Committee are prepared to state that the requirements, as respects instrumental means, are so small as to constitute no difficulty whatever. The selection of an Astronomer to whom the superintendence of the undertaking could confidently be intrusted is felt by the Committee to be the first position to be secured, in order to ensure success; but they are not as yet empowered to make any recommendation in this respect.

Further than this no difficulty is foreseen with respect to suitable assistants in the execution of the work, inasmuch as the details call for nothing beyond intelligence, method, and the degree of zeal which may be expected to come of itself to a task so directly competitive with a similar undertaking. Many young men may with ease be found who would readily and efficiently take their part in such a work, for such inducement of pay and position as would ordinarily be offered in such a case; and though the annual amount of salaries would be larger than the Society has hitherto applied to Government to provide at their suggestion, the total is but little in comparison with what has been granted in past years for other scientific purposes. There is the great advantage, in this instance, that the work is perfectly defined by the parallel Survey in the North, and that the return for the outlay may be regarded as certain beforehand.

"4. Lastly, the Committee have to mention that the Director of the Madras Observatory has notified his intention of executing a portion of this work forthwith at his station, which, apart from the accidents of life and health in an unhealthy place, may be expected to somewhat reduce the extent of the area to be surveyed independently of him. But it will be borne in mind that Madras is 13° N. of the Equator, and that this notice from Mr. Pogson can at most slightly modify the general proposal before the Council.

"5. The Committee have agreed to report thus generally, in the first instance, on the state of the case, and on the questions involved in the proposal which might otherwise be thought to entail difficulties with which it is in fact not surrounded, and abstain from making special recommendations till the inclination of the Council to move in the matter has been ascertained."

The Council, which this day retires, have thus endeavoured by preliminary inquiry to clear the ground for action in this matter on the part of their successors in office, to whom they commend the further promotion of the undertaking.

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*Papers read before the Society from February* 1862 *to February* 1863.

1862.

Mar. 14. Discovery and Observations of Comet III. 1861. Mr. Bond.

On the Perturbations of *Uranus* and Mass of *Jupiter*. Mr. Safford.

On the Proper Motion of *Sirius* in Declination. Mr. Safford.

Moon Culminators, Greenwich, Sydney, and Cape of Good Hope. Mr. Scott.
Observations of Comet II. 1861. Mr. Mackay.
On the Irregularity of the Proper Motion of *Sirius*. M. Auwers.
Observations at Malta: Discovery of New Star in Trapezium of *Orion*. Mr. Lassell.
Transit of *Mercury*, &c. Mr. Abbott.
Ephemeris of Long-Period Variable Stars for 1862. Mr. Pogson.
On some Variable Stars. Mr. Knott.
Observations of Transit of *Mercury* and Solar Eclipse. M. Bulard.
On Astronomical Refraction. Mr. Yates.
Occultation observed at Highbury. Mr. Burr.
Orbit of ξ *Ursæ Majoris*. Mr. Breen.
Observations of Solar Eclipse, Dec. 31, 1861. M. D'Arcy.

Apr. 12. On Solar Spots. M. Jeanjaquet.
Rediscovery of *Alhazen*, a supposed Lunar Crater. Mr. Birt.
Opposition of *Mars*, &c. Lieut. Gilliss.
Observations of Encke's Comet. Mr. Hartnup.
On the Disappearance of a Nebula in *Coma Berenices*. Sir J. Herschel.
Note of a Circular Dark Spot on the Sun's Disk. Mr. Lummis.
Transit of *Mercury*. Mr. Abbott.

May 9. Observation of a Meteor, April 14, 1862. Mr. Gorton.
Transit of the Shadow of *Titan* across the Disk of *Saturn*. Rev. W. R. Dawes.
On Heliotypography. Mr. De La Rue.
On Hind's Nebula in *Taurus*. M. O. Struve.
Results of Meridional Observations of Small Planets, March 1862. Mr. Airy.
On the Asteroid *Feronia*. Dr. Peters.
Observations at Cambridge of Comet II. 1861. Mr. Adams.
Extract of Letter to Mr. Carrington on the Intra-Mercurial Planet. Mr. Littrow.
Extract of Letter to the Astronomer Royal on the Transit of *Mercury*. Mr. Todd.
On Encke's Comet: Extract of Letter to the Astronomer Royal. Sir T. Maclear.
On Lambert's Theorem for Elliptic Motion. Mr. Cayley.
On a Solar Spot and on a Transit of *Titan* over *Saturn*. Mr. Gorton.
Observation of the Appearance of the Ansæ of *Saturn*. Mr. Carpenter.

On the Variable Star U *Geminorum*. Mr. Baxendell.
Transit of the Shadow of *Titan*. Mr. Lockyer.
Observations of Comet I. 1861. Sir T. Maclear.
Announcement of New Instrument for Indian Trigonometrical Survey. Col. Strange.

June 13. Results of Meridional Observations of Small Planets. Mr. Airy.
On the Appearance of *Saturn's* Ring. Mr. Birt.
On the Solar Energy in the Autumn of 1861 and Spring of 1862. Mr. Birt.
Occultation: Disappearance of *Jupiter's* 1st Satellite. Mr. Talmage.
Extract of Letter from Dr. Winnecke. Rev. R. Main.
Disappearance of B.A.C. 4923 at the Moon's Dark Limb, 1862, June 9. Rev. R. Main.
Letter to the Astronomer Royal. M. Hoeck.
Extract of Letter to the Astronomer Royal. Mr. Scott.
On the Missing Nebula in *Coma Berenices*. M. Chacornac.
On some Phenomena attending the Disappearance of *Saturn's* Ring, May 19, 1862. Mr. Huggins.
On the Periodical Changes in the Belts and Surface of *Jupiter*. Mr. Huggins.
Saturnian Phenomena. Rev. W. R. Dawes.
On the Appearance of *Jupiter* without a Visible Satellite, Sept. 1843. Rev. W. R. Dawes.
On the Proposed Parallax. Observations of *Mars*, 1862. Prof. Smyth.
On the Solution of Kepler's Problem. M. De Gasparis.
Description of a New Aplanatic Eye-piece for Telescopes. Mr. Burr.
On the Mean Places of certain Fixed Stars. M. C. Rümker.
On a Solar Spot. Mr. Hodgson.

Nov. 14. On the Cluster $\kappa$ *Crucis*. Mr. Abbott.
Observations of the Horizontal Refraction of the Sun. Major Lang.
On the Irregularities of the Motion of *Procyon*. Mr. Lynn.
On the Practicability of Observing the Occultation of Stars by the Moon at Sea. Mr. Smith.
Extract of a Letter from Dr. Wolfers. Rev. R. Main.
Measures of the Planet *Mars*. Rev. R. Main.
Observations of Comet II. 1862. Mr. Knott.
Ditto ditto Mr. Hartnup.
Ditto ditto Mr. Chalmers.
Ditto ditto Lieut. Chimmo.
Observations of a Comet. Mr. Abbott.
On the Extraordinary Brightness of the Lunar Spot *Aristarchus*. Dr. Stothardt.

On a Remarkable Chain of Lunar Craters. Mr. Birt.
On a New Method of obtaining the Value of the Divisions of a Transit Level. Capt. Noble.
On Combining the Angles of Regular Polyhædrons. Mr. Drach.
On Excentric and Centric Force. Mr. Pratt.
On the Identity of the Triple Star H. I. 13. Rev. W. R. Dawes.
Second Series of Observations of Double Stars at Madras. Mr. Powell.
On the Motion of a Pendulum with especial reference to the Foucaultian Experiment. Mr. Wackerbarth.
On Aluminium Bronze. Col. Strange.
Telescopic Appearance of *Mars*. Mr. Grove.
Letter to Mr. De La Rue on the True Figure and Dimensions of the Earth. M. Von Gumpach.
Account of Observations with the Elchies Equatoreal. Prof. C. P. Smyth.
Observations of Comet II. 1862. Rev. R. Main.

Dec. 12. On the Variable Star R *Vulpeculæ*. Mr. Knott.
A last Letter from Capt. Jacob. Prof. C. P. Smyth.
Letter presenting Helioautographs. Rev. Prof. Selwyn.
Observations on *Saturn*. Mr. Wray.
A New and Close Approximation to the Circumference of the Circle, &c. Mr. Drach.
On the Gregorian Calendar. Mr. Drach.
Observations of a Comet. Mr. Cockburn.
On the Form of Lenses for Negative Eye-piece of Telescopes. Mr. Airy.
On the Great Solar Spot of August 4, 1862. Mr. Howlett.

1863.
Jan. 9. Extract of Letter to the Astronomer Royal. M. Auwers.
Letter, with Observations of *Saturn* made at Pulkowa and Greenwich. Mr. Airy.
Observations of *Mars*. Mr. Joynson.
Observations of a Comet in Australia. Mr. Tebbutt.
Observations of *Asia* (67). Mr. Hartnup.
Observations of Comet II. 1862. M. Romberg.
Results of Meridional Observations of Small Planets. Mr. Airy.
On the Observations made with the Elchies Equatoreal. Rev. W. R. Dawes.
Elements and Ephemeris of *Feronia* (71). Dr. Peters.
On the Elchies Equatoreal. Mr. Knott.
Note on U *Geminorum*. Mr. Baxendell.

***List of Public Institutions and of Persons who have contributed to the Society's Library, &c. since the last Anniversary.***

Her Majesty's Government.
The Secretary of State for War.
The Secretary of State for India.
The Lords Commissioners of the Admiralty.
The Board of Trade.
The Postmaster General.
Royal Society of London.
Royal Asiatic Society.
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Royal Institution.
Royal United Service Institution.
Geological Society.
Linnean Society.
Zoological Society.
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Society of Arts.
British Meteorological Society.
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Institute of Actuaries.
British Horological Institute.
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Liverpool Mercantile Marine Association.
Literary and Philosophical Society at Manchester.
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Royal Dublin Society.
Royal Society of Van Dieman's Land.
Imperial Observatory, Paris.
Imperial Observatory, Vienna.
Royal Observatory, Munich.
Royal Observatory, Brussels.
Royal Observatory, Madrid.
Observatory, San Fernando.
Observatory at Bonn.
L'Académie Impériale des Sciences de l'Institut de France.
Le Dépôt Général de la Marine.
Le Bureau des Longitudes.
L'Académie Impériale de Dijon.
The Society at Cherbourg.
Imperial Academy of Sciences, Vienna.
Royal Academy of Sciences, Berlin.

The Society of Physics, Berlin.
Royal Academy of Sciences, Munich.
Royal Academy of Sciences, Brussels.
Royal Academy of Sciences, Göttingen.
Royal Academy of Sciences, Amsterdam.
Royal Society, Naples.
Royal Swedish Academy.
Imperial Academy, St. Petersburg.
Hungarian Academy.
Academy of Sciences, Batavia.
Society at Berne.
Society at Upsala.
Society at Geneva.
Society at Leipsig.
Austrian Board of Marine.
Canadian Institute.
Government of the United States.
Committee of Harvard College.
Observatory of Harvard College.
American Academy of Arts and Sciences.
American Philosophical Society.
Smithsonian Institution.
Franklin Institute.
Committee of the American Coast Survey.
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Editor of the Parthenon.
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Editor of the Reader.
Editor of the Intellectual Observer.
Editor of the Sculptor's Journal.

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*Address delivered by the President, Dr. Lee, on presenting the Gold Medal of the Society to M. Argelander.*

Gentlemen,—The established custom of this Society enjoins me to undertake the important duty of addressing you on the termination of our year of office, and of resigning into your hands the trust which you confided to me. But my gratification on this occasion is mixed with regret, inasmuch as this is the last time that I shall have the honour of speaking officially to you as President of the Royal Astronomical Society. The first idea which now occurs to me, is that of requesting you to accept of my respectful and grateful thanks for the honour which you have conferred upon me in placing me in this chair,—an honour which will be the source of pleasing reflections during the remainder of my days; and, whilst feeling that only a zeal for your interests, and in a life-long desire to promote the advancement of our noble Science, I can pretend to vie with those eminent men who have preceded me *in this Presidency*.

The opportunities of great discoveries in the regions of space, or in the theory of the grand and simple laws which rule the motions of those vast bodies which decorate the heavens, have not entirely passed away. The times of Kepler and of Newton, of Lagrange and of Bradley, will not again return. Where they reaped the rich harvest of astronomical truths we can but glean. We must rest content with the investigation of what has been well termed, by Sir John Herschel, "Residual Phenomena."

The principal Observatories of Europe, and of Africa, and of Asia, and of America, are now engaged in the gradual accumulation of systematic observations, and in recording facts, which, hereafter reduced to order, will serve as bases of verification of the accepted theories of our time, or will themselves become the germs of new theories, or the elements of undiscovered laws among the Astronomers of future ages.

Within the comparatively short period of the existence of this Society, of which Sir William Herschel was the first President in 1820, and of which, two of the Council, and two of the three original Secretaries are still existing, and shining as stars of the first magnitude in their diverse regions of Science, and all of them being Members of the Royal Society, what a world of splendid incidents, bearing on its pursuits, have been revealed to skill and perseverance!

Such are, The improved knowledge of Cometary Motion; the investigation of the Nebular Theory; the repetition of the Cavendish Experiment; the "Resisting Medium" discussion; the taking of Transits by Galvanism; the Chronoscopic intercourse between Observatories; the Electric Telegraph, and its application to the longitudes of places; the Undulatory Movement of Light; the application of the new and surprising art of Photography to the Sun, the Moon, and even the double stars; the detected affinity between the Solar Spots and Terrestrial Magnetism; the orbits of Binary Stars; the lines of the Solar Spectrum; the triumphant winning of Neptune, and the finding of upwards of seventy Minor Planets between *Mars* and *Jupiter*.

Amongst those things deserving of record in the progress of celestial observations within the last two years, it would be unpardonable in me, were I to pass over in silence the dauntless excursions in the firmament undertaken by our indefatigable colleague, Mr. Glaisher, and his fearless companion, Mr. Coxwell. At one time much was expected to accrue to Meteorological Science from aeronautic expeditions; but I think it may be safely conceded, that from the days of Gay Lussac and Biot to our own, little has been done deserving of scientific record until the important discoveries which these two gentlemen have brought to our knowledge by their successful balloon ascents during the preceding year.

*Such* are the great and interesting results extracted from

the recesses of nature, by skill and perseverance, in the brief span of time to which I have alluded; and it is gratifying to recollect the practical aid which some of our Members have rendered towards the advancement of these invaluable branches of Science, as well as the Society's liberal recognition of all the labourers in this vineyard, whatever clime or country they pertained to. This is well exemplified by noting the awards to merit made from year to year by our successive Councils; and in this, as you are all aware, it has been a principle well understood and acted upon in the adjudications, that the mere official product of public establishments, however admirably executed, is not to be placed in competition with those spontaneous investigations which spring from the voluntary ardour of individual exertions, unless improved methods are introduced.

In illustration of this, I may remark that our exponents of high approbation of astronomical labours are seen in the bestowal of our honorary distinctions.

Since the founding of this Society in 1820, there have been forty-three medals awarded to merit, of which nineteen have been bestowed on foreigners, and twenty-four on our own countrymen, a very fair proof of the cosmopolite principles on which we have hitherto acted.

I now come to the subject which is the principal object of this Address, namely, the Council's award of the Gold Medal for this year to F. W. A. Argelander, the distinguished Professor of Astronomy at the University of Bonn, in Prussia, —a gentleman whose high claims will occur to you all, on a recollection of his able superintendence of the several observatories of Abo, Helsingfors, and Bonn, the various works which he has published, and the numerous communications which he has made to the scientific public in Baron de Zach's *Correspondance Astronomique*, and the *Astronomische Nachrichten*. The Observatory of Bonn was founded by the laudable and intelligent spirit of the Kingdom of Prussia, and the whole of the expenses of the establishment are supported by the well-bestowed liberality of that country.

A large portion of the Professor's researches has been devoted to that crucial element, the Proper Motions of the Stars. The general method of ascertaining these has been by comparing two sidereal Catalogues with a considerable interval between their epochs, thereby to detect any difference which does not correspond with the amount of the precession of the equinoxes; yet, as the earlier catalogue is more liable to the consequences of instrumental errors than the more delicate observations of recent days, the real truth can only be extracted from repeated operations and improved methods. Numbers of supposed erratic bodies are cleared off the working list at each succeeding course of investigation; but those which are thereby confirmed and proved, become of the gravest importance for

all future investigations of the Stellar Laws. To this problem Argelander applied his experience and skill with such success, that in the year 1835 he published his well-known Catalogue of 560 Stars, with their motions as determined by his observations in Finland. Under this examination he assumed, that of the 560 stars, 390 of them had proper motions exceeding 0″·1 per annum; and from this he deduced a very interesting result relative to the movement of the Solar System towards a point in the heavens, presenting a near agreement with that which was roughly conjectured fifty-two years before, by our peerless extra-meridian Præses, the late Sir William Herschel.

By the refined investigation of the Abo results, the co-ordinates of the point in question, referred to the mean equinox of 1792, are

R.A. = 259° 47′·6 with a probable error of 3″·28
Dec. = + 32° 29′·5 do. 2″·20

The course of these studies led the Professor to estimate the comparative magnitudes of the stars by the unassisted eye, and he arrived at the conclusion, that in the space between the North Pole and 30 degrees of Southern Declination, there are 3256 stars visible to the naked eye.

Many faint stars had been included in former celestial charts, while brighter ones had been neglected. Argelander found about twenty stars which, though visible to the naked eye, were not contained in any trustworthy Catalogue. The importance of thus giving to future astronomers the means of judging whether any gradual and very slow changes are taking place in the relative magnitudes is sufficiently evident. He also watched assiduously for the changes attributed to those singular bodies, the Variable Stars. Hence followed his remarkable disquisition from his own personal observations, on the double maximum and minimum curve of *β Lyræ*, in 1843; a result which, though differing in particulars, confirmed the researches of our countryman (Goodricke) in 1784; to whom is due the discovery of the changes of brightness in *β Lyræ*. This memoir, perhaps, stimulated the attention of modern observers upon the strange phenomena which these stars exhibit. This course he has followed out with signal success; and in our *Monthly Notices* for June 1856, we have copied from the *Astronomische Nachrichten* his able suggestions respecting a "Method for determining the Brightness of the Minor Planets."

In the same *Notices* for December 1861 is a Report on the progress of the admirable Star-Charts in course of execution at Bonn. It is communicated by our indefatigable colleague, Mr. Carrington, who received it from Dr. Krüger, by the direction of Professor Argelander.

This is a singularly interesting Report. It describes the various parts of the magnificent Catalogue, which will embody

30,000 (accurately) determined stars. It is, therefore, well deserving of a reperusal by all our Members, as it explains lucidly what portions of the Stellar Zones are finished and fully published. Also, the part which was in the press, and what share remained in the press at that time, are duly detailed; and it must be a matter of gratification to an English reader, that the Catalogues of our Members,— Groombridge, Johnson, and Carrington,— have been closely consulted in the construction of this great product of science; and they are associated with the eminent foreigners, Lalande, Piazzi, Bessel, Struve, Schwerd, and Rümker.

The remark at the conclusion of this communication is deserving of our full attention, and, I think, approbation; namely, "That the Fellows of this Society, and all to whom "this account comes, cannot fail to admire the stately progress "of this enormous work, which, simple in its conception, and "free from insurmountable difficulties in execution, would "*appal* many an astronomer by its vast extent."

The Zone Observations of Dr. Argelander, contained in the first two volumes of his work, and made at Bonn, are of great importance. This extensive and valuable work may be looked upon as a continuation of Bessel's Zone Observations. These latter were limited by the parallels of 15° South and 45° North Declination. The Zones contained in Dr. Argelander's first volume extend from 45° to 80° of North Declination, and those in the second volume from 15° to 31° of South Declination. As in Bessel's Zones, the observations of each Zone are accompanied by an Auxiliary Table for reducing the apparent places of the stars observed, to the mean places for a given epoch. For the Zones in the first volume, the epoch chosen is the beginning of 1842, and for the second the beginning of 1850. The former Zones contain 26,424 separate observations, of which about 4000 are duplicate, so that the number of different stars contained in them is about 22,000. The latter, or Southern Zones, contain 23,250 observations, of which about 5600 are duplicate; so that the number of separate stars is about 17,600.

Thus we have a total of nearly 40,000 stars, whose places have been determined with very considerable accuracy, the probable error of a determination of Right Ascension corresponding to an equatoreal interval scarcely exceeding $0^s.1$, and that of a determination of Declination scarcely exceeding $1''$, except for some of the more Southern Zones.

Bessel's Zones comprise about 75,000 observations of nearly 62,000 different stars. Mr. Carrington's excellent Redhill Catalogue contains the places of nearly 4000 stars between the Pole and 81° of North Declination, the observations being made on a somewhat more extended plan than those of Bessel and Argelander.

Thus, by the junction of the labours of these three astronomers, the places of above 105,000 stars lying between the

North Pole and 31° of South Declination have been well determined. It would be highly desirable that Zone observations on a similar plan to that of Bessel and Argelander, should be undertaken by some zealous astronomer in the Southern Hemisphere, so that the survey might be extended to the South Pole.

Vast as is the number of stars whose places have thus been determined, it is far exceeded by the number recorded in Dr. Argelander's Survey of the Northern Heavens, which forms the basis of his beautiful new Star-Charts, and for which your Council have awarded him the Medal of the Society.

The first section of this work, forming the third volume of the *Bonn Observations*, contains the approximate places of 110,984 stars between 2° South and 20° North Declination. The second section, forming the fourth volume, contains the approximate places of 105,075 stars between 20° and 40° of north declination.

Dr. Argelander's plan of survey extends to the whole of the Northern heavens; but, in the hope that a similar survey may be undertaken in the Southern hemisphere, he includes the first two degrees of Southern declination, for the sake of affording means of comparison between the two works.

Within the above-mentioned limits the Charts were to contain all stars down to the 9th magnitude, as far as possible all the brighter ones of the 9-10 magnitude, and as many of the remainder of this class as circumstances permitted. The magnitudes were not to be more than a half-class in error, and the positions in both co-ordinates not more than one minute in error, so that every star in the Charts might be at once found again in meridian instruments; and that, with respect to neighbouring stars, no doubt should occur which was meant. All gross errors in existing Star-Catalogues were also to be noticed and corrected, whether they related to the magnitudes or positions of the stars.

As an instance of the utility of this work of Dr. Argelander, it may be mentioned that this survey immediately supplied proper stars to be compared with *Mars*, with the view of determining his parallax by equatoreal observations during the last autumn. Also, it enables us at once to identify stars that have been compared with planets and comets. Also, to detect and correct any errors of entire minutes, and such-like errors, which not unfrequently occur in recorded observations or in Catalogues.

It is said that Professor Challis has made great use of Dr. Argelander's last published Catalogue in identifying stars observed with the transit and mural circle of the Observatory of Cambridge, and in correcting or verifying the minutes of right ascension and north polar distance given by the observations. In cases of discordances between the results of observation and the places of a working catalogue of zodiacal stars,

founded on the British Association Catalogue, and those of Weisse and Lalande, he was generally able to determine on which side the error lay, by means of Argelander's Catalogue; and the large number of such instances afforded good evidence of its trustworthiness and accuracy.

Argelander began his Zones in the spring of 1852, and finished them in the spring of 1859.

The number of stars to be registered is, in all, about 310,000, as follows:—

| | | | |
|---|---|---|---|
| 0° | to | 20° | 105,000 |
| 20 | to | 40 | 93,000 |
| 40 | to | 60 | 69,000 |
| 60 | to | 80 | 37,000 |
| 80 | to | 90 | 5,000 |
| | | | 309,000 |

Such have been the laborious and persevering exertions of our experienced Associate to render the knowledge of our European skies as perfect as, humanly speaking, is possible by his admirable Zones in continuation of Bessel's, his beautiful Sidereal Charts, and his unequalled Survey of the heavens of the Northern Hemisphere, which comprises all the first nine magnitudes of the stars; and for which your Council have awarded Professor Argelander the highest honorary distinction which it is in their power to bestow.

My anticipation, therefore, is, that the Members will, by an unanimous vote, confirm this decision of their Council; which Council I can affirm, in all its consultations, has freely devoted the best of its judgment to this result. Indeed it has willingly employed its time to the promotion of the interests of science, and of your reputation, in all its operations during my occupation of this Chair.

The President then addressed the Foreign Secretary thus:—

Admiral Manners,—In transmitting this Medal to Professor Argelander, as an acknowledgment by this Society of his zeal, perseverance, ability, and industry, in sidereal investigation, be good enough, with your usual courtesy and kindness, also to convey to him, with our best wishes for his health and happiness, the deep interest which we have taken in his past, and which we must continue to take in his future, labours for the promotion of Astronomy.

The Meeting then proceeded to the election of the Officers and Council for the ensuing year, when the following Fellows were elected:—

*President:*

G. B. Airy, Esq. M.A. F.R.S. Astronomer Royal.

*Vice-Presidents:*

Arthur Cayley, Esq. M.A. F.R.S.
Warren De La Rue, Esq. F.R.S.
John Lee, Esq. LL.D. F.R.S.
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Richard Hodgson, Esq.
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Admiral R. H. Manners.

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Rev. Professor Selwyn, B.D.
Edward J. Stone, Esq. M.A.
Lieut.-Col. A. Strange.
Charles V. Walker, Esq. F.R.S.

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# MONTHLY NOTICES

OF THE

# ROYAL ASTRONOMICAL SOCIETY.

VOL. XXIII. *March* 13, 1863. No. 5.


G. B. AIRY, Esq., Astronomer Royal, in the Chair.

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***On the Fringes of Light observed by M. Poulain at Goree during the Total Eclipse, 31st December, 1861.*** By M. Hermann Goldschmidt.

(*Extract from a Letter addressed to the Astronomer Royal.*)

I have seen in the *Monthly Notices* (which the Royal Astronomical Society kindly send me) the interesting drawing you laid before the Society, representing the fringes of light observed by M. Poulain at the total eclipse observed at Goree on the 31st Dec. 1861.

Allow me, Sir, to give you some details on the same object, concerning the conversation with the Spanish countryman who journeyed for some hours in our company in going from Vitoria to Bilbao. He stated that before the totality of the Eclipse of 1860, seen by him on a high mountain, yellow spots were seen flitting over their white clothes from West to East. He compared the colour with the most yellow flowers (like the *Ibericum*) we saw on the road. There is, indeed, no useful scientific information in this relation, but it confirms the direction of the movement observed by myself on the annular Eclipse of the year 1820, and mentioned by me in the descrip-

tion of the Solar Eclipse of the year 1860 (see *Astron. Nachrichten*, No. 1340, p. 308). It may be of some interest to give you the whole description of what I had seen in Frankfort-on-the-Maine on the afternoon of the 7th September, 1820.

I was in my uncle's house, one hundred and twenty paces only from my father's, when the darkness began. I left the house; but I had scarcely gone twenty paces in the street, from East to West exactly, when I saw the moving shadows coming towards me, covering the large and deserted street, and passing under my feet. Their movement was slow, for otherwise I could not have perceived them so distinctly, with the eyes so nearly fixed on them; the movement was not rapid. The aspect was like the shadow of smoke in sunshine—regular in translation; the forms, like rhomboids of four or six inches in diameter, and sometimes more extensive, were mixed with superposed shadows of the same size, and ribbon-like forms. The inner spaces particularly, filled with round spots softly melted and mixed with the whole in veiled grey transparence, gave to the phenomenon a somewhat mysterious appearance. Thus, looking to the paved street, these ribbons and spots flitted under my feet, till I arrived at a group of men near my father's house, after having made one hundred steps in contemplating this strange apparition. At this moment the annular eclipse was forming: the light of the Sun ran around the Moon in a very singular manner—it seemed like a fluid mass. I can truly estimate the time from the moment when I saw the shadows till the forming of the annulus—an interval of two minutes and thirty seconds.

I spread a large white cloth at my feet in Vitoria, but I had no time to look on it, absorbed by other business and the people who rushed in.

I had recommended this observation to Captain Manheim, who really saw the fringes at Constantine in the year 1860.

*Paris, February 2nd*, 1863.

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*On the Determination of the Longitude of Valencia, in Ireland, by Galvanic Signals, in the Summer of* 1862. By G. B. Airy, Esq., Astronomer Royal. (Abstract.)

The Astronomer Royal adverts to the operation effected in 1844 for the determination of the longitude of the Feagh Main Station, in Valencia, by the transmission, ten times in both directions, of thirty pocket-chronometers, between Greenwich and Feagh Main; a transit instrument having been erected at Feagh Main, and the chronometers being compared with the transit-clocks at Greenwich and Feagh Main. Advantage was taken of the passage through Liverpool and

Kingston to determine the longitudes of the Liverpool Observatory and of a station near Kingston Harbour. The longitudes then found were

| | | m s |
|---|---|---|
| Liverpool Observatory, West of Greenwich | | 12 0·05 |
| Kingstown Station | ,, | 24 31·20 |
| Feagh Main Station | ,, | 41 23·23 |

For details, he refers to *Mem. Roy. Ast. Soc.*, vol. xvi., or *Greenwich Observations*, 1845.

After the completion of galvanic communication between London and Valencia (consequent on the laying down of the Atlantic Telegraph), and the connexion, through the agency of the London District Telegraph and the British and Irish Magnetic Telegraph, between Greenwich and the London Offices of the B. and I. M. Telegraph Company, the Astronomer Royal, with the assured assistance of Sir Charles T. Bright and E. B. Bright, Esq. (Engineer and Managing Officer of that Company), and of T. B. Moseley, Esq., (their London Resident Officer), decided on repeating the determination by galvanic signals. The principal motive for this was, the desire of co-operating with M. Struve in establishing an Arc of Parallel from Valencia in the West to Orsk, on the river Oural, in the East. The station now adopted was not that of Feagh Main, but a place in Knightstown, in the vicinity of the Telegraph Office.

Sir Henry James and Captain Clarke, R.E., gave great assistance in the loan of observing hut, the conveyance of instruments, and other ways; and the Knight of Kerry and R. J. Leckie, Esq., contributed all the local aid that was required.

It was determined that local time at Valencia should be found entirely by observation of zenith distances, and a 12-inch Altazimuth (by Simms) was lent for this purpose by T. Coventry, Esq. The signals were simply movements of a galvanometer-needle at each station, the current being given at every $15^s$ nearly by an auxiliary clock.

The observers, Mr. Dunkin and Mr. Criswick, remained at Valencia from June 11 to July 23. During this time there were few opportunities of star-observation in consequence of the continued bad weather, and few opportunities of observing galvanic signals in consequence of interruptions at the Telegraph Office of Mallow. On the whole, only six nights of effective signals with good determinations of local time were obtained. The Valencia observer throughout was Mr. Dunkin, and the Greenwich observer of signals Mr. Ellis.

On reducing the altazimuth observations, great anomalies presented themselves in the determination both of latitude and of time. After carefully discussing the observations, and

making some experiments at Greenwich, it became clear that the zenith-distances were always given too great by about 4″. The cause of this anomaly is not known. On applying the corresponding correction, the results were made harmonious. It is remarked, however, that very little depended on this correction, the observations having been well balanced on the East and West sides of the meridian.

The signal-observations were then discussed nearly in the same way as in the determination of the longitude of Brussels (*Mem. Roy. Ast. Soc.*, vol. xxiv.), and the results were the following :—

| | m | s |
|---|---|---|
| Time occupied in the passage of the current | 0 | 0·129 |
| Longitude of the Knightstown Station .... | 41 | 9·81 |

By the kindness of Captain Clarke a geodetic connexion was made between the Feagh Main Station and the Knightstown Station, and their geodetic difference of longitude was found to be $13^{s}\cdot56$. Applying this to the former determination for Feagh Main, it is found that the old operations would have given for Knightstown $41^{m}\,9^{s}\cdot67$. The agreement of this with that found from the galvanic operation is very remarkable, and it proves that implicit confidence may be placed in the old determinations for Liverpool and Knightstown.

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*On the Movement of the Solar System in Space, deduced from the Proper Motions of* 1167 *Stars.* By Edwin Dunkin, Esq., of the Royal Observatory, Greenwich.—(Abstract.)

The investigation which forms the subject of this Memoir, may be considered as a supplement or addendum to that of the Astronomer Royal, *On the Movement of the Solar System in Space*, published in vol. xxviii. of the Society's *Memoirs*. The method of calculation differs in no respect from that previously used, excepting that the Proper Motions of a much greater number of stars have been combined in producing the results. It is intended, therefore, that this paper should be read in connexion with the memoir of Mr. Airy, as the mathematical explanation, which has been given in detail by him, is not generally repeated on this occasion.

In this memoir, the Proper Motions of nearly all the stars contained in the Catalogues of the Rev. R. Main, have been adopted, numbering in all 1167 stars. In Right Ascension they are scattered in nearly equal proportions over the twenty-four

hours, and in Declination, about two-thirds are situated in the northern hemisphere. The stars are arranged into groups or divisions, according to magnitude, in conformity with the researches of W. Struve, whose value of $r$ has been adopted. The number of stars included in each division, and Struve's value of $r$, are as follows:—

| Division. | Magnitude. | Value of $r$. | Number of stars in each Division. |
|---|---|---|---|
| 1 | 1 | 1·00 | 9 |
| 2 | 1,2 2 2,3 | 1·71 | 55 |
| 3 | 3,2 3 3,4 | 2·57 | 146 |
| 4 | 4,3 4 4,5 | 3·76 | 238 |
| 5 | 5,4 5 5,6 | 5·44 | 330 |
| 6 | 6,5 6 6,7 | 7·86 | 368 |
| 7 | 7,6 7 7,8 8 | 11·34 | 21 |

The method which the Astronomer Royal has proposed for determining the direction of solar motion, as being entirely free from the objections attaching to those of former investigations, "and, indeed, unobjectionable on the score of accuracy, consists merely in removing the primary geometrical notions from the apparent movements of the bodies in space. It is the obvious and simple method of treating the linear movements of the Sun, and of each star, by the use of rectangular co-ordinates. This method is in itself absolutely independent and complete, and requires no assumption of a point determined by preceding investigation."

For convenience of reference, the final symbolical equations from which the different numerical equations are immediately derived on two extreme suppositions, are inserted in the memoir. For the first supposition, it is assumed that the irregularities of Proper Motion are due to chance-error of observation; while in the second supposition they are considered to be entirely due to a peculiar motion of the stars.

The numerical equations for X, Y, Z, have been formed for each division on both suppositions, $-X$ representing the annual linear motion of the Sun in the direction of the first point of *Aries*, $-Y$ the motion in the plane of the equator towards that point whose right ascension is ninety degrees, and $-Z$ the motion towards the north pole of the equator. The solution of the sums of these equations gives the following values, neglecting very small terms depending on $n'$ and $q$.

On the first supposition:

$$X = +0{\cdot}0428 + 1{\cdot}2349 \times n'$$
$$Y = +0{\cdot}2776$$
$$Z = -0{\cdot}1818 + 3{\cdot}5792 \times q$$

On the second supposition:

$$X = +0\cdot0406 + 2\cdot3747 \times n'$$
$$Y = +0\cdot3696$$
$$Z = -0\cdot1735 + 6\cdot1090 \times q.$$

From the above the following expressions are deduced:—

On the first supposition:

$$R = 0\cdot3346 \quad + 0\cdot1580 \times n' - 1\cdot945 \times q$$
$$A = 261^\circ\ 14'\ 0 - 4\cdot3454 \times n'$$
$$= 261\ 14\ 0 - 248^\circ\cdot97 \times n'$$
$$D = +32\ 55\ 0 - 0\cdot3057 \times n' - 8\cdot9811 \times q$$
$$= +32\ 55\ 0 - 17^\circ\cdot52 \times n' - 524^\circ\cdot54 \times q$$

On the second supposition:

$$R = 0\cdot4103 \quad + 0\cdot2350 \times n' - 2\cdot5826 \times q$$
$$A = 263^\circ\ 43'\ 9 - 6\cdot3480 \times n'$$
$$= 263\ 43\ 9 - 363^\circ\cdot71 \times n'$$
$$D = +25\ 0\ 5 - 0\cdot2672 \times n' - 13\cdot4937 \times q$$
$$= +25\ 0\ 5 - 15^\circ\cdot31' \times n' - 773^\circ\cdot13 \times q.$$

The preceding results have all been reduced, on the assumption that the distance of the stars varies inversely to their magnitude, regardless of the amount of Proper Motion. It is by no means improbable, however, that the few stars of the fourth, fifth, and sixth magnitudes, whose Proper Motions are extravagantly large, are really near stars, and as such might be placed with propriety in the first division. The results of a transfer of this kind, in addition to others of a similar nature, are given in the memoir. A glance at the values of X, Y, Z, determined by these different assumptions, shows distinctly that they are not relatively improved by any deviation from Struve's law of the mean distances of the different groups of stars with respect to these exceptional stars.

The value of R, or the Sun's proper motion as viewed from a star of the first magnitude, expressed in seconds, resulting from this investigation, differs very slightly from that determined by M. Otto Struve. His value is 0·3392. There is very little doubt, therefore, that a value near the mean of these numbers may be assumed as fairly representing the annual motion of the Sun and solar system towards the point to which the direction is assigned, so far as any result can be obtained by the use of the known apparent proper motions of the stars.

To show the numerical evidence of the probability that the values previously given should in some measure represent the motion of the solar system, the sums of the squares of the observed Proper Motions in Parallel and North Polar Distance

were formed, and these have been compared with the squares of the residual errors after the corrections depending on solar motion have been applied. This comparison was only made on the second supposition. The results are exhibited in the memoir for each division; the total sums of the squares are as follows:—

Sum of squares of Motion in Parallel { Uncorrected = 78·7583 / Corrected = 75·5831

Sum of squares of Motion in N.P.D. { Uncorrected = 63·2668 / Corrected = 60·9084

"The reader must draw his own conclusions on the comparison of the uncorrected and corrected results given above. It appears to me that our fundamental suppositions rest altogether on a very slender basis; and the results warrant the question whether we have much ground to infer that the Proper Motions of the stars are produced principally by the motion of the Sun and its system in space. It may be, and probably such an inference is partially true, that these apparent motions in the positions of the stars are due to some compound effect resulting from causes some of which have yet to be discovered; though it is very remarkable that different astronomers, with totally different methods of investigation, should, without exception, fix the point in the heavens to which the solar motion is directed, within a few degrees of each other."

The memoir concludes with a comparison of the position of this point as determined by different astronomers, from the date of Sir William Herschel's original paper in 1783, to the present time. The author remarks on the extraordinary agreement of these researches:—"To say the least, this confirmation of result after result, would seem to show that the Proper Motions of the stars *must* be connected with the motion of the Sun in the direction of the point in the heavens indicated above. But the further consideration of this I must leave for others, merely remarking, that the grounds upon which we have been working are uncertain to a considerable extent, which uncertainty will scarcely be removed until our knowledge of the distances of the stars is increased, or until the Proper Motions themselves are re-determined from unexceptionable observations, made at both epochs, with the improved instruments of modern Observatories."

A table is appended to the memoir, containing the principal elements from which the numerical co-efficients have been computed. The stars are arranged in their respective divisions, in order of Right Ascension, excepting that all stars of North Declination are grouped together, the same being also done for stars of South Declination.

*On the Rating of Chronometers.* By J. Hartnup, Esq.

At the Liverpool Observatory, Mr. Hartnup has been recently engaged in discussing the sea-rates of nearly two thousand chronometers, for the purpose of ascertaining the average error for voyages of different lengths. On comparing the rates at sea with the rates of the same chronometers obtained at the Observatory, the importance of attending to the thermal correction has manifested itself more strongly than ever; and, in addition to this, the rates are often found to increase or diminish with such regularity from one month to another, that a correction for this may also be very frequently applied with great advantage. Mr. Hartnup has, therefore, been induced to make considerable alterations in his method of testing and giving the rates of chronometers, with the view of ascertaining the rates of these corrections more accurately, and of rendering the application of them more simple.

The following is an example:—

From the week ending November 1, 1862, to the week ending January 24, 1863, the temperatures to which the chronometer was exposed were 55°, 70°, 85°, 70°, 55°, and so on a succession; it, therefore, requires five weeks for a complete series of rates in the above-named temperatures, and these were obtained between October 25 and November 29, the observed rates being as follows:—

| | Temp. | Rate. |
|---|---|---|
| | ° | s |
| Nov. 1 | 55 | +0·9 |
| 8 | 70 | +0·4 |
| 15 | 85 | −0·7 |
| 22 | 70 | +1·6 |
| 29 | 55 | +2·1 |

Now the rates in 55° for the week ending November 1 being 0ˢ·9 gaining, and in the same temperature for the week ending November 29 being 2ˢ·1 gaining, the difference is 1ˢ·2, which, divided by 4, the number of intervening weeks, gives 0ˢ·3 for the weekly increase of gaining rate.

We, therefore, have for November 15:—

| | | | |
|---|---|---|---|
| | Mean daily rate | losing 0·7 in | 85° |
| From Nov. 8 and 22 | ,, | gaining 1·0 in | 70 |
| From Nov. 1 and 29 | ,, | gaining 1·5 in | 55 |

And weekly acceleration of gaining rate 0·3

With the above data the error on Greenwich Mean Time has been calculated for each week subsequent to November 15, by adding 0ˢ·3 × by the number of weeks to that mean daily

rate which corresponds with the temperature to which the chronometer was exposed, multiplying the sum by 7, and adding the amount thus obtained to the error for the preceding week. That is, Calculated Daily Rate = Daily Rate Nov. 15 for same temperature + $0^s{\cdot}3$ × number of weeks since Nov. 15. For example, for the week ending Jan. 17, temperature 70°, Calculated Daily Rate = $1^s{\cdot}0 + 9 \times 0^s{\cdot}3 = 3^s{\cdot}7$, which, multiplied by 7, is = $25^s{\cdot}9$, and Calculated Error for Jan. 17 = Calculated Error for Jan. 10 + $25^s{\cdot}9 = 0^h\ 3^m\ 58^s{\cdot}1 + 25^s{\cdot}9 = 0^h\ 4^m\ 24^s{\cdot}1$.

In this way the following Calculated Errors in Greenwich Mean Time have been obtained, and compared with those found by observation, from November 22, 1862, to January 24, 1863, and the Observed — Calculated Errors range from + $3^s{\cdot}8$ to — $8^s{\cdot}5$ for the eight weeks subsequent to the last observed error and rate used in the calculation.

| | Temperature to which Chronometer was exposed. | Error on G.M.T. Calculated. | Observed. | Obs$^n$ — Cal$^n$. |
|---|---|---|---|---|
| 1862. | | h m s | h m s | s |
| Nov. 22 | 70 | 0 2 12·4 | 0 2 14·5 | +2·1 |
| 29 | 55 | 2 27·1 | 2 29·4 | +2·4 |
| Dec. 6 | 70 | 2 40·4 | 2 42·6 | +2·2 |
| 13 | 85 | 2 43·9 | 2 47·6 | +3·7 |
| 20 | 70 | 3 1·4 | 3 5·2 | +3·8 |
| 27 | 55 | 3 24·5 | 3 27·1 | +2·6 |
| 1863. | | | | |
| Jan. 3 | 70 | 3 46·2 | 3 47·5 | +1·3 |
| 10 | 85 | 3 58·1 | 3 57·6 | −0·5 |
| 17 | 70 | 4 24·0 | 4 18·9 | −5·1 |
| 24 | 55 | 0 4 55·5 | 0 4 47·0 | −8·5 |

If the corrections for temperature and acceleration of rate had not been applied and the $0^s{\cdot}7$ losing rate found for the week ending November 15 had been used, then, by exposing the chronometer to a temperature of 55° for the eight weeks, the Greenwich Mean Time by the chronometer would have been wrong nearly four minutes; and if, on the other hand, the rate for 55° had been used and the chronometer exposed for the eight weeks to 85°, the error would have been only a few seconds. In the former case the defective thermal compensation and acceleration of rate both tend to increase the error, while in the latter they nearly neutralise each other. It is, therefore, not surprising that we frequently hear of so much difference being found between the sea and land rates of chronometers; nor can it be expected but that we meet with very discordant results in attempting to find the average error to which chronometers are liable at sea. The average error for a voyage of eight weeks, found from data given at foreign ports, is a little under one minute; but while the

Greenwich Time shown by ten per cent of the chronometers from which this result is obtained, is found to be nearly free from error, there are also ten per cent in which the average error is upwards of four minutes.

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## *On the Parallax of certain Stars.* By M. Auwers.

(*Extract of a Letter to the Astronomer Royal, dated Gotha, 1863, Jan. 16.*)

Since I communicated to you the notices on the Parallaxes of two stars, I have made an examination of Johnson's observations of 61 *Cygni*, in the hope that the Oxford heliometer, if the observations made by it are treated in such a manner as to make the known systematic faults of heliometer-distances exercise the least possible influence on the results sought, may give a decisive voice for one of the two irreconcileable values for the Parallax, namely Bessel's of 0″·370, and Struve's and mine of 0″·553.

I have taken as the subject of calculation the quantity 0″·705 × dist. of 61 *Cygni* from B.A.C. 7320 — dist. of 61 *Cygni* from Lalande 41030, instead of the distances themselves, or their immediate differences; my hopes, however, have not been confirmed.

The whole series of observations gave the Parallax =0″·426; the residual errors, however, are of such a nature that we cannot look upon the observations as sufficiently represented with this value of Parallax. Still less is this the case, if, instead of using the annual variation of the above-given differences that follows from the measures themselves, we assume that which follows with greater security from the meridian observations, with which the Parallax comes out 0″·402. But if we calculate separately the observations of the eleven first months (40 in number), and those of the remaining seven months, we obtain from the former the Parallax = 0″·526, from the latter only = 0″·192; the first of these values agrees very well with Struve's and mine, whilst the second departs materially from all determinations, and seems to show that the observations made after June 1853 are affected with some systematic error.

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## *On the Parallax of the Fixed Stars.* By M. Krüger.

(*Lettre de M. Krüger à M. Le Verrier.*)

The following letter appears in the *Bulletin Météorologique*, 1863, Feb. 9th.

"Permettez moi de vous communiquer le résultat de deux séries d'observations faites à l'aide de l'excellent héliomètre de Bonn sur des parallaxes d'étoiles fixes. La première se rapporte à l'étoile Lalande 21258, 8·9$^{eme}$ grandeur, dont le grand mouvement propre a été signalé par M. Argelander dans le No. 1288 des *Astronomische Nachrichten*. J'ai trouvé par 36 comparaisons avec deux étoiles, dont l'une précède, l'autre suit, à peu près sur le parallèle:—

"Parallax annuelle de J. Lalande 21258 = + 0″·260 avec l'erreur probable ± 0″·02.

"La seconde recherche concerne l'étoile de 9$^{eme}$ grandeur, 17415–6 dans le Catalogue de M. Oeltzen, pour laquelle M. Argelander a trouvé un mouvement annuel de 1·2 secondes. Au moyen de 45 comparaisons avec deux étoiles convenablement situées, le résultat suivant a été évalué: —

"Parallax annuelle de Oeltzen 17415–6 = + 0″·247, avec l'erreur probable ± 0″·021.

"*Helsingfors*, 1863, *Janvier* 31."

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## *Results of the Meridional Observations of Small Planets; Occultation of a Star by the Moon; and Phenomena of Jupiter's Satellites; observed at the Royal Observatory, Greenwich, in the month of January*, 1863.

(*Communicated by the Astronomer Royal.*)

### *Victoria* (19).

| Mean Solar Time of Observation. | | R.A. from Observation. | N.P.D. from Observation. |
|---|---|---|---|
| | h m s | h m s | ° ′ ″ |
| 1863, Jan. 24 | 13 15 13·8 | 9 30 39·00 | 88 23 52·01 |
| 27 | 13 0 43·6 | 9 27 56·07 | 88 17 0·01 |

### *Bellona* (28).

| Mean Solar Time of Observation. | | R.A. from Observation. | N.P.D. from Observation. |
|---|---|---|---|
| | h m s | h m s | ° ′ ″ |
| 1863, Jan. 24 | 13 16 13·9 | 9 31 39·32 | 78 17 31·21 |
| 27 | 13 2 17·9 | 9 29 30·68 | 77 53 19·56 |

## *Urania* (30).

| Mean Solar Time of Observation. | | R.A. from Observation. | N.P.D. from Observation. |
|---|---|---|---|
| | h m s | h m s | ° ′ ″ |
| 1863, Jan. 19 | 9 16 14·6 | 5 11 17·83 | 65 10 55·38 |
| 20 | 9 12 1·8 | 5 11 0·86 | 65 12 47·74 |
| 23 | 8 59 40·0 | 5 10 26·74 | 65 18 13·61 |
| 24 | 8 55 37·0 | 5 10 19·58 | 65 19 55·63 |
| 27 | 8 43 40·9 | 5 10 11·21 | 65 24 41·73 |

## *Ariadne* (43).

| Mean Solar Time of Observation. | | R.A. from Observation. | N.P.D. from Observation. |
|---|---|---|---|
| | h m s | h m s | ° ′ ″ |
| 1863, Jan. 24 | 12 33 49·8 | 8 49 8·19 | 76 17 52·45 |
| 27 | 12 18 41·8 | 8 45 47·45 | 76 7 59·58 |

## *Europa* (52).

| Mean Solar Time of Observation. | | R.A. from Observation. | N.P.D. from Observation. |
|---|---|---|---|
| | h m s | h m s | ° ′ ″ |
| 1863, Jan. 7 | 12 11 25·0 | 7 19 38·26 | 72 5 2·33 |
| 20 | 11 9 18·9 | 7 8 37·25 | 71 10 13·91 |
| 23 | 10 55 11·3 | 7 6 16·94 | 70 57 32·27 |
| 24 | 10 50 30·5 | 7 5 31·95 | 70 53 26·28 |
| 27 | 10 36 33·7 | 7 3 22·58 | 70 40 57·38 |
| 29 | 10 27 21·3 | 7 2 1·71 | 70 32 47·00 |

All the observations of N.P.D. have been corrected for refraction and parallax.

## *Occultation of a Star by the Moon.*

| Day of Obs. | Phenomenon. | Moon's Limb. | Mean Solar Time. | Observer. |
|---|---|---|---|---|
| | | | h m s | |
| 1863, Jan. 27 | Disappearance | Dark | 5 9 49·1 | D. |
| 27 | Reappearance | Bright | 6 28 30·6 | D. |

## *Phenomena of Jupiter's Satellites.*

| Day of Observation. 1863. | Satellite. | Phenomenon. | Mean Solar Time. | Observer. |
|---|---|---|---|---|
| | | | h m s | |
| Jan. 24 | I. | Eclipse disapp. | 13 53 45·8 | C. |
| 27 | II. | Eclipse disapp. | 13 8 34·9 | D. |

The initials D. and C. are respectively those of Mr. Dunkin and Mr. Criswick.

*Occultations observed at Highbury.* By T. W. Burr, Esq.

1863, Feb. 27th, 15 *Geminorum* disappeared at $8^h\ 13^m\ 21^s{\cdot}4$, Local Sidereal Time. March 2d, $\alpha$ *Cancri* disappeared at $10^h\ 28^m\ 34^s{\cdot}5$, Local Sidereal Time.

Both occultations were by the Moon's dark limb. The star 15 *Geminorum* was very faint, and in no case could the emersion be accurately observed. Telescope as usual, my 4 ft. 4 in. Equatoreal, $3\frac{3}{8}$ inch aperture. Power 173. Longitude, $24^s$ W.

*Highbury, March 12th,* 1863.

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*On the Visibility of Stars in the Pleiades to the unarmed Eye.* By G. B. Airy, Esq., Astronomer Royal.

To the greater number of star-gazers, with what are commonly considered "good eyes," I believe that Ovid's remark as to the visible number of *Pleiades* still applies:—

"Quæ septem dici, sex tamen esse solent."

I find, however, that one of the members of my family habitually sees seven stars, and, on rarer occasions, twelve. On the clear evening of 1863, Feb. 15th, a map of the visible stars was drawn from ocular view, and, on comparing it with

North.

a map drawn from Bessel's measures, I had no difficulty in identifying the stars as those which Bessel has marked by the following numbers:—

| | |
|---|---|
| No. 1 | No. 17 (bright) |
| 2 (bright) | 29 |
| 4 | 34 (brightest = *η Tauri*) |
| 4 (bright) | 38 |
| 11 (bright) | 41 (bright) |
| 13 | 42 (not quite so bright) |

No. 42 is the seventh star, which is seen only by acute eyes.

---

## *Observations of Mars.* By W. Lassell, Esq.

I have the pleasure to present to the Society herewith a series of drawings of the planet *Mars* during the late favourable opposition.*

The more deeply-shaded parts of the series are generally the blue and neutral-tint portions — the lighter shades represent the ruddy or deep-orange parts — and the unshaded parts, the brightest portions, which are generally about the circumference. The faint lines exterior to the disk represent approximately the position of the ecliptic with respect to the phenomena of its surface. The times given are Greenwich Mean Time.

The drawings are *tracings* of the original drawings made at the telescope's side. Towards the North Pole there was generally a bright part, less marked, however, than the conspicuous spot at the South Pole. This is most striking, as might be expected, in those phases in which the neighbouring portion is most shaded. On the 22d Sept. (No. 3 drawing) a bright marginal crescent, on the following side, extended nearly over half the circumference. No. 4 (24th Sept.) was drawn from a very sharp image and with great care. On the 25th Oct. (No. 15) the long band of white near the North Pole was remarkably plain. The phenomena were best seen with a Power 760. On the 27th Oct. (No. 16) the planet exhibited with 760 a very fine view of delicate markings, very difficult to draw. There seemed to be a protuberance of the limb about (*c*), where also the limb was whiter than at the parts adjacent. A long white tract was visible at (*b*) only a little inferior to the brightness of the white spot at (*d*). There was a blueish-white district at (*a*). The dark or neutral-tint portion seemed shaded off there into a lighter hue of the same

* These drawings will probably appear in lithograph in the volume of *Memoirs*.— Ed.

colour—not at all into the coppery tinge. The ruddy portion was much more uniform, as indeed it generally is, than the blue or green portion. The only distinct mark I saw upon it was a curved streak near the South Pole, which appeared to be a very slight shade of the blue colour. Several of these remarks apply generally to most of the drawings; but I make them here because the view obtained this evening was one of the very finest I have ever had. Nov. 4th (No. 17), power 760, the planet has already become obviously gibbous. The blue portion has in its darkest part a very irregular and hard outline, which is strikingly analogous to the coast-line of a terrestrial continent, much broken by bays and inlets. I find it impossible to represent its outline faithfully. There are also delicate markings on the red or brown portion near the bright spot, which baffle my skill. The view with this high power is at times surprisingly sharp.

In watching *Mars* for so long a period I expected to have been able to observe returns of the same phase according to the law of rotation, but I have not found it possible to do so except very imperfectly. To watch the progress of any individual spot during a few hours observation on any one evening, or after the interval of one day or two, is easy enough; but when the same phases ought again to occur after an interval of time, I find they can rarely be certainly recognised.

For instance, the phase given

| | | | |
|---|---|---|---|
| Sept. 13, | ought nearly to recur | Oct. | 22 |
| ,, 20 | ,, ,, | ,, | 29 |
| ,, 22 | ,, ,, | ,, | 31 |
| ,, 24 | ,, ,, | Nov. | 2 |
| ,, 25 | ,, ,, | ,, | 3 |
| ,, 27 | ,, ,, | ,, | 5 |
| ,, 29 | ,, ,, | ,, | 7 |
| Oct. 11 | ,, ,, | ,, | 19 |
| ,, 13 | ,, ,, | ,, | 21 |
| ,, 15 | ,, ,, | ,, | 23 |
| ,, 17 | ,, ,, | ,, | 25 |
| ,, 18 | ,, ,, | ,, | 26 |
| ,, 21 | ,, ,, | ,, | 29 |

but if the drawings nearest these dates are severally compared, the resemblance is certainly traceable in most instances, but not with that uniformity which would indicate an unchanged surface. I therefore think, as has been justly remarked by Mr. Grove in the *Monthly Notice* for December, that if the variously coloured portions do generally represent land and water, their aspect must be greatly modified by the transit of clouds of great extent, density, and variety of form.

It will be seen that there is much less detail in the later drawings, which are scarcely comparable with the early ones on account of the greatly increased distance of the planet.

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*Proceedings of the Madras Observatory.* By Norman Pogson, Esq., Director of the Observatory.

The following Memorandum, relating to the current and the proposed work of the Madras Observatory, has been transmitted by Mr. Pogson to the Astronomer Royal:

"The proceedings of the Madras Observatory during the past two years, although not yet before the public, nor indeed likely to be so at present, may not be without sufficient interest to warrant a brief recapitulation. The new Transit Circle was finally completed and commenced its career of service on the 1st June, 1862. It yields the most satisfactory results as regards steadiness in all its corrections, and is being employed for the determination of the positions of comparison stars used for equatoreal observations, of all observable variable stars, of such small planets as come to opposition south of the equator, and generally for the formation of a Catalogue of new small southern stars as zero points for the Southern Celestial Survey, now in hand. This latter work, announced in the *Monthly Notice* of last June, was commenced on the first night of this year, and will be proceeded with rapidly, aided, it is hoped, by an experienced assistant whom it is intended to request Prof. Argelander to nominate, so soon as the sanction already granted by the local government has been confirmed by the supreme authorities.

"The Variable-Star-Atlas is just beginning to be engraved, and as from its nature it can only be proceeded with on perfectly clear moonless nights, must necessarily be some time in hand—interfering certainly to some extent with the Southern Survey, but not being in any way delayed by the contemporaneous execution of that far higher and more comprehensive work now fairly in hand. A useful Catalogue of Stars observed under the management of Lieut.-Col. Worster, when acting Astronomer, is in an advanced state of reduction. Observations of the fine comets of 1858, 1861, and 1862, and of several small planets, await the determination of the comparison stars employed by the Transit Circle, all which will, it is hoped, be secured in the ensuing fine season.

"The Magnetical and Meteorological records, carried on hourly for the twenty years 1831–1860, are wearily advancing as regards reduction and publication. The former are printed *up to 1854*, the latter a year further on. These heavy arrears

form the most trying portion of the observatory duties, and most grievously interfere with the astronomical department at the present time. Twenty districts, each averaging about seven talugs, are now made to send rain returns to the Observatory, and the arrangement of these, more especially the sifting and summing up of the registers of eight years past, will be no trifling additional task.

"The planet *Mars* was duly observed as proposed when in opposition, for the investigation of the Solar Parallax, both with the Equatoreal at rising and setting, and with the Transit Circle at meridian passage; but owing to pressure of other immediate duties, the observations have not yet been sufficiently reduced for submission to their respective head-quarters, viz., Greenwich and Pulkova.

"Some highly desirable longitude determinations are under contemplation throughout India, at no distant period, by means of the electric telegraph, and as a first step thereto, the construction of a chronograph has been sanctioned by the Local Government. A new Equatoreal of larger aperture and a superior Anemometer are expected to be supplied shortly. The present instruments are all in fair order, having been cleaned up and repaired by Mr. F. Doderet, the mathematical instrument maker to the Public Works Department, from which his services were transferred to the Observatory throughout the first half of the past year."

*Madras*, 1863, *Jan.* 26.

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At a recent meeting of the Royal Society, our Fellow, Mr. Huggins, in conjunction with Dr. W. A. Miller, the Treasurer of that Society, communicated a Note on the "Lines in the Spectra of some of the Fixed Stars," as an earnest of the results of twelve months' observations of some 30 or 40 stars, the Moon, *Jupiter*, and *Mars*, which are to follow.

The valuable observations of Dr. Miller on the photographic spectra of the metals, &c., are too well known to require mention here, did not a recent deduction from them hold out great promise of doing for the *temperature* of the Sun and stars what the magnificent generalisation of Kirchoff has done for their *chemical constitution*. It has been shown that the spectra of metals vary with the temperature of the source of light, the higher the temperature the more refrangible being the vibrations. Thus, by introducing lime and sulphate of magnesia into the oxyhydrogen jet, the flame of which, according to Bunsen, cannot exceed 14580° Fahr., a spectrum has been obtained corresponding in length with that of the Sun; by employing the

electric spark between magnesium terminals, however, a very decided band is obtained beyond the limits of the solar spectrum. Now, as magnesium is well known to exist in the Sun, it would thus appear that the temperature of that luminary is not so high as that of the electric spark, and that approximately it is not higher than that of the oxyhydrogen flame.

Next in importance to a form of apparatus which enables the lines to be clearly seen, must be reckoned the arrangement by which they are measured and referred to Fraunhofer's lines, the universally accepted standard of comparison. Mr. Huggins, having proved the exact coincidence of the sodium band with the solar line D on his apparatus (which is attached to his equatoreally-mounted 8-inch refractor), has employed it as the point from which all measures are taken, the sodium band being compared directly with the stellar spectrum under observation, both being in the field of view of the telescope. To guard against every source of error, however, in such delicate investigations, the spectra of one or two of the metals have also been compared with the stellar spectrum in some cases and it is the intention of the authors of the Note to supplement their observations with these additional direct comparisons in each instance.

It may be mentioned that since this valuable communication was made to the Royal Society, Dr. Miller and Mr. Huggins have succeeded in obtaining microscopic photographs of the spectra of *Sirius* and *Capella*. Diagrams of the lines in *Sirius*, *α Orionis*, and *Aldebaran*, which had been observed and measured with great accuracy, accompanied the paper.

J. N. L.

An account, by Prof. Secchi, of his latest observations on the same subject, together with a sketch of the Spectra of *α Orionis*, *Aldebaran*, *Sirius*, *Rigel*, and *Pollux*, will be found, *Ast. Nach.*, No. 1405.—Ed.

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A communication has been received from M. de Gasparis, "*Sur une Equation pour le Calcul des Orbites Planetaires.*" This has already been published in the *Ast. Nach.*, No. 1405, and in the *Comptes Rendus* of the Academy of Paris.

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## *Companions of Sirius.**

M. Goldschmidt has announced to the Academy of Sciences at Paris the discovery of several stars in the neighbourhood of *Sirius*:—

"The unexpected discovery of a companion of *Sirius*, by Mr. Clark, confirms in a striking manner the existence of a celestial body in the neighbourhood of *Sirius*, theoretically predicted by Bessel, Peters, Auwers, and Safford. The companion perceived by Mr. Clark—is it illumined by *Sirius*, or a Sun shining by its own proper light? In the latter case, we should have two stars physically combined, forming a system of double stars. Having tried to see this companion with my feeble instrument of 46-lines aperture, I was able to perceive it at moments; I was, moreover, very much astonished to see that this companion was not alone, and that there were several other stars in the neighbourhood of *Sirius*, at distances varying from 15″ to 1′. The first (*c*) of these stars, or companions, is remarkable for its proximity to the central star; its position, approximately estimated, corresponds to an angle of 95°, reckoned from east to north. This new companion is sufficiently visible at moments, with the precautions necessary for such an observation; for all these minute stars, five in number, are immerged in the light of *Sirius*. The discovery was made with an object-glass of 46 lines; Mr. Clark employed an object-glass of 216 lines (18 inches). The difference of light was, therefore, as 1 to 22. The figure represents the six satellites (image reversed).

Position of the Satellites *b*, *c*, *d*, *e*, *f*, *g*, in regard to *Sirius* (*a*).

"These researches have been made independently of the remarkable theories of MM. Peters, Auwers, and Safford. Conversing with M. Radau, I was able to establish that there was a striking agreement between the data of M. Auwers and the observation of the Star No. 1 (*Ast. Nach.*, No. 1371)."

M. L'Abbé Moigno remarks that M. Goldschmidt remains faithful to the motto on the Medal of the Society, "*Quidquid nitet notandum.*"

* Translated and the woodcut extracted from No. 5 of *Les Mondes*, the weekly scientific journal edited, in place of the *Cosmos*, by M. L'Abbé Moigno.—Ed.

The following Errata in the *Monthly Notices*, together with some previously corrected, were communicated to the Editor by the Astronomer Royal.

Vol. XX., 1860.

Page 368, line 39, *for* *α Orionis*, *read* *ε Orionis*.

Vol. XXI., 1861.

Page 143, line 6, *for* outlines, *read* outliers.
— 196, — 12, *for* 1811, *read* 1861.
— 211, — 26, *for* third satellite, *read* first satellite.
— 244, — 15, *for* Best, *read* Birt.

Vol. XXII., 1862.

Page 278, line 8, *for* 18 inches, *read* 13 inches.
— 295, — 22, *for* ring of the shadow, *read* shadow of the ring.
— 322, — 14, *for* 161, *read* 164.

Vol. XXIII., 1863.

Page 70, line 12, *for* mere, *read* more.
— 75, last line but one, *for* their being, *read* with their being.
— 79, line 9, *for* 880·54, *read* 180·54.
— 92, — 26, *for* 133·6, *read* 183·6.
— 100, — 19, *for* place, *read* phase.
— 113, — 6, *for* P.E., *read* P.M.
— 120, — 14, *for* 65, *read* 98.
— 120, — 17, *for* 69, *read* 99.
— 120, — 24, *for* 117, *read* 116.

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# MONTHLY NOTICES

OF THE

# ROYAL ASTRONOMICAL SOCIETY.

VOL. XXIII. *April* 10, 1863. No. 6.


G. B. AIRY, Esq., President, in the Chair.

Lieut.-Col. Patrick Stewart, R.E., 8 Lower Belgrave Street,
and
J. Wm. Harris, Esq. M.R.C.S.L., Southernhay, Exeter,
were balloted for and duly elected Fellows of the Society.

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***Determination of the Sun's Mean Horizontal Equatoreal Parallax, from a Comparison of Corresponding Observations of N.P.D. of Mars and Stars, made at the Royal Observatory, Greenwich, and the Government Observatory, Williamstown, Victoria, Australia, during the Opposition of*** 1862. By E. J. Stone, Esq.

In his Tables of *Mars*, published in the *Annals of the Imperial Observatory*, Paris, 1861, M. Le Verrier remarks that it is impossible to reconcile the observations of *Mars* with theory without attributing to the perihelion a motion greater than any which can be obtained, except by a sensible increase of the received planetary masses; that the necessary agreement between theory and observation could be obtained by increasing the received value of the mass of the Earth in proportion to the Sun's mass, by not less than a tenth part, but that such an increase in the received value of the Earth's mass would necessitate a corresponding increase in the received value of the Sun's mean equatoreal horizontal parallax of a thirtieth part.

M. Le Verrier deduced the same result from a discussion of the latitudes and the motion of the node of *Venus*. The dif-

ficulties raised in the theory of *Mercury*, although not removed, were slightly diminished by the same increase of the Earth's mass.

In his Solar Tables, M. Le Verrier has adopted the value $8''{\cdot}95$ for the mean equatoreal horizontal solar parallax; this value was obtained by determining from observation the coefficient of the lunar equation and assuming the mean lunar parallax and data furnished by the theories of Precession and Nutation.

The way in which M. Le Verrier has thus evolved from the theories of *Venus*, the Earth, and *Mars*, the necessity of a value of the mean solar parallax much greater than the usually received value $8''{\cdot}57$, and not differing greatly from $8''{\cdot}95$, must render it extremely probable that the true value of the Sun's mean parallax does not differ greatly from that quantity.

It is the object of the present paper to lay before the Society a redetermination of the Sun's mean equatoreal horizontal parallax.

Some time since Robert L. S. Ellery, Esq., the Director of the Government Observatory, Williamstown, Victoria, Australia (Longitude E. $9^h\,39^m\,39^s{\cdot}3$, Latitude S. $37^\circ\,52'\,6''{\cdot}6$), forwarded to the Astronomer Royal a fine series of meridian declination observations of *Mars*, made during the period extending from 1862, August 20, to the middle of the following November. These observations the Astronomer Royal has kindly placed in my hands for comparison with the corresponding Greenwich observations. I have thus deduced 22 independent determinations of the Sun's mean solar parallax.

The method of reduction pursued has been as follows:—The North Polar Distances of *Mars* at the Greenwich and Williamstown transits, and the geocentric distances of the planet, have been obtained, where necessary, by interpolation from the *Nautical Almanac*. The Greenwich observations were then compared with the tables; and from the system of errors thus exhibited a curve was roughly drawn to represent the change of error: the only use of this curve was to determine the small change of error of tabular places between the transits of *Mars* over the meridians of Williamstown and Greenwich.

The factors of the Sun's mean horizontal equatoreal parallax in the expressions for the parallax in declination were then calculated, using the Astronomer Royal's value of the ratio of the principal axes of the earth, viz. $\frac{299}{300}$; and the observations of *Mars* compared with the same stars at Greenwich and Williamstown. In weighting the observations, I have considered the probable error of an observation of the centre of *Mars*, deduced from observations of the two limbs, equal to the probable error of a good star observation: the weights are the strict theoretical weights, and I have considered all

observations as equally good, unless the observer has expressed himself dissatisfied with the observation at the time of making it. All the Greenwich observations that could be combined with observations at Williamstown, without trusting to the interpolation of change of tabular error for more than two days, and without using different stars of comparison at the two stations, have been so combined, and the results are given. The following are the separate results:—

| 1862. | Mean Horizontal Equatoreal Parallax. | Weight. | 1862. | Mean Horizontal Equatoreal Parallax. | Weight. |
|---|---|---|---|---|---|
| | ″ | | | ″ | |
| Aug. 25 | 9·240 | 3·1329 | Oct. 3 | 9·024 | 2·9241 |
| 27 | 9·646 | 3·4969 | 8 | 8·962 | 2·8561 |
| 28 | 9·416 | 2·2201 | 9 | 9·024 | 2·8224 |
| Sept. 3 | 8·868 | 1·7689 | 11 | 8·748 | 2·7556 |
| 10 | 9·161 | 4·2436 | 18 | 8·497 | 0·5329 |
| 11 | 8·756 | 4·0000 | 22 | 8·929 | 2·4025 |
| 16 | 8·844 | 3·7249 | 24 | 8·559 | 1·4884 |
| 17 | 9·148 | 2·8224 | 29 | 8·708 | 3·6100 |
| 21 & 22 | 8·684 | 4·3264 | Nov. 3 | 8·620 | 0·4356 |
| 23 | 9·074 | 4·3681 | 9 & 10 | 8·932 | 2·2201 |
| 25 | 9·052 | 2·9584 | 12 | 9·006 | 1·5876 |

The mean result is 8″·932, and if we assume the probable error of a single observation = 0″·25, the probable error of the above result would be 0″·032.

The comparison of the Greenwich and Williamstown observations, therefore, leads to the value 8″·932 ± 0″·032 for the Sun's mean horizontal equatoreal parallax,—a value differing but slightly from the value assumed by M. Le Verrier in his Solar Tables.

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M. Otto von Struve, Associate of the Society, gave an account of a remarkable local deviation in the direction of gravity, which has lately been observed in Russia. It is the more remarkable from its occurring in a country which is totally free from mountains, and which, though slightly undulating, may be described as a very level plain country.

On computing, upon the best elements for the figure of the earth, the longitudes and latitudes of the points in the Russian triangulation, it was found that the observed co-latitude of the Observatory of Moscow was about 8″ greater than that given by the geodetic connexion with other well-determined points of the survey. To put this beyond doubt, it was compared with numerous triangulation-stations in its neighbourhood, and the

results, with only such discordances as may always be expected, were all of the same kind. The high character of Professor Schweizer, the observer at Moscow, placed the validity of the astronomical determination beyond all suspicion. Professor Schweizer, then, with such assistance as he could command, repeated the observations at numerous points in the vicinity of Moscow. The following is the general result:

Upon the map below there will be remarked three somewhat irregular lines, nearly in the direction E.N.E. and W.S.W. Along the central line the observed co-latitudes agreed sensibly with the geodetic co-latitudes. To the north of that central line, for a considerable distance, the observed co-latitudes are too great, and to the south of that central line they are too small. The upper and lower lines show the places of maximum discordance; the upper line passes sensibly through the Observatory of Moscow. The disturbances appear to have been traced to about one degree of longitude on each side, east and west, where their magnitudes are reduced to about one-half of those in the neighbourhood of Moscow.

The amount of disturbance near Moscow, in relation to the distance of a place from the central line, is nearly as follows:—

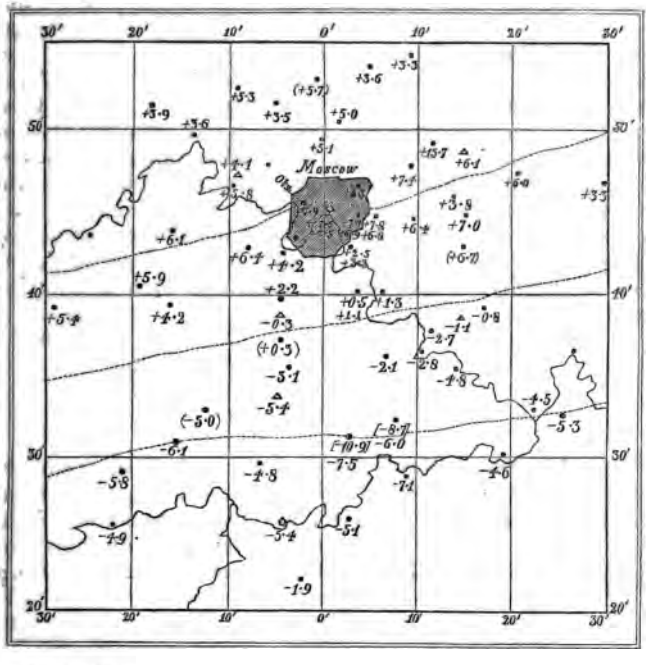
| | | | | |
|---|---|---|---|---|
| At distance 0 | ... ... ... ... ... | disturbance = 0 | | |
| 3·8 versts | = 2·5 English miles | ... | ... | ... 2″·22 |
| 12 | ... = 8 | ... | ... | ... ... 7·80 |
| 20 | ... = 13 | ... | ... | ... ... 5·15 |
| 26·59 | ... = 18 | ... | ... | ... ... 2·10 |
| 34 | ... = 23 | ... | ... | ... ... 0 |

Its magnitude is sensibly the same, but with opposite signs, at equal distances north and south of the central line. The deviation at distances not exceeding 8 miles from the central line, is not less than $\frac{1}{60}$th part of the angle made by the verticals. Its sign is that corresponding to a deficiency of matter beneath the central line; and it does not apparently admit of explanation by any other supposition, as by an excess of density of the earth's crust in two places, one north and the other south, because beyond the limits above stated there is no trace of sensible disturbance.

According to Professor Schweizer's calculations, the volume of deficiency of matter, of the same density as the earth's crust, must be 1·2 cubic German geographical miles (the German geographical mile is $\frac{1}{15}$th of a mean degree of latitude). This supposes that the deficiency is at no great depth below the central line. If the density of the earth's crust, in that part, be only partially diminished, the volume of matter so affected must be increased in a corresponding proportion.

M. O. Struve, struck with the importance of these observations, and with the probable advantage of pursuing them

further, has applied for, and has obtained, from the Imperial Government, the means of enabling Professor Schweizer to examine the local disturbances at numerous points, in a district of considerable extent, connected with the general survey by a secondary triangulation. The small map below embraces but a portion of the country to be thus examined. It is intended that the comparison of observed and geodetic co-latitudes shall




The shaded space is the city of Moscow. The observatory is in its upper left-hand corner.

The figures at other stations denote the excess of observed co-latitudes, in seconds. Those inclosed in brackets are less certain.

be extended, especially to the east and west, until the discrepancies disappear. When these limits are ascertained, it is intended, on Mr. Struve's suggestion, that longitudes and azimuths shall be observed at numerous stations. The elevation of different points, and the general form of the district, will also be ascertained by levelling, in order to eliminate the very small effects which may be produced by the inequalities of the surface. And pendulum-experiments are to be made, for ascertaining the effect of the disturbing cause on the force of gravity.

The extension of the survey is already begun by the Imperial General-Staff (Etat-Major). And for the other operations, Professor Schweizer will receive all the assistance which the influence of Russian scientific bodies can obtain.

The President remarked on this interesting communication, that it was one of great value, not merely for the importance of the results obtained, but also as an instance of extraordinary combination of different powers of different officers, directed each in the most advantageous way. Numerous instances had occurred of anomalies in the direction of gravity, but there had been few instances in which a superior officer had at once perceived, as Mr. Struve had done, the importance of the phenomena thus revealed, and the advantage of tracing them further, not only by extension over a larger area, but also by the introduction of other classes of observation; in which application for further powers had been made; in which the Government had with so much liberality responded to the call; and in which, by the zeal and ability of the officer immediately intrusted, the results, as far as they had been pursued, had been so happily worked out, and results of even greater importance were in prospect.

G. B. A.

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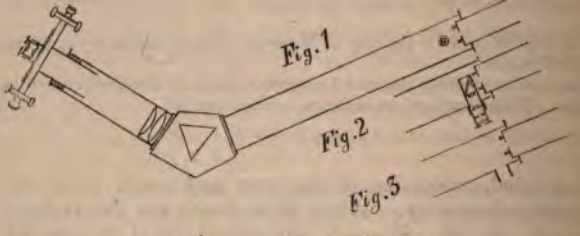
The Astronomer Royal gave an oral account, illustrated by drawings, of the apparatus which had been prepared at the Royal Observatory, Greenwich, for the observation of the spectra of stars, and of some of the principal results obtained. In the drawing below, the first figure represents the entire ap-




paratus, in section; the second and third figures represent the right-hand portion of the apparatus in a section through the axis of the long tube, but at right angles to the former section.

In fig. 1, the smaller tube at the right-hand is for insertion in the socket upon the breech-piece of the telescope of the great equatoreal. To carry the apparatus steadily, (great accuracy *of position* is not needed) a temporary frame is screwed to the

sides of the telescope tube. The right-hand tube is thrust into the socket so far that the image of the star is formed in the moderately small hole in the inner end of that smaller tube. The pencil of light from the object-glass, which has converged to form the image of the star, then diverges and falls in a wide and divergent state upon the prism; after emergence it is received on a combination of lenses, which causes the pencils for the different colours to converge. It is seen thus that a spectrum may be formed at the place of the micrometer; it is necessary now to explain how breadth is given to the spectrum.

For this purpose the prism is not placed in the position of minimum deviation, or the position in which the angles of incidence and emergence are equal. It is so inclined that the angle of emergence is greater than the angle of incidence. With this arrangement, the change in the degree of divergence of the extreme rays of the pencil is different as regards (on the one hand) rays in the upper and lower parts of the pencil, or in the plane of the paper, and (on the other hand) rays in the plane perpendicular to the paper. The difference is such that, when after passing through the lenses the former have converged so as to form a pure spectrum at the place of the micrometer, the latter have passed convergence, and therefore the spectrum has breadth. The position of the prism, which gave a convenient breadth to the spectrum, was determined by trial. It is necessary to remark that the lenses must not be achromatic; they are in fact made of dispersive flint glass; if achromatic, the spectrum would have been formed in a plane inclined to the plane of the micrometer. The whole of these peculiarities were calculated numerically on geometrical theory before the construction was attempted.

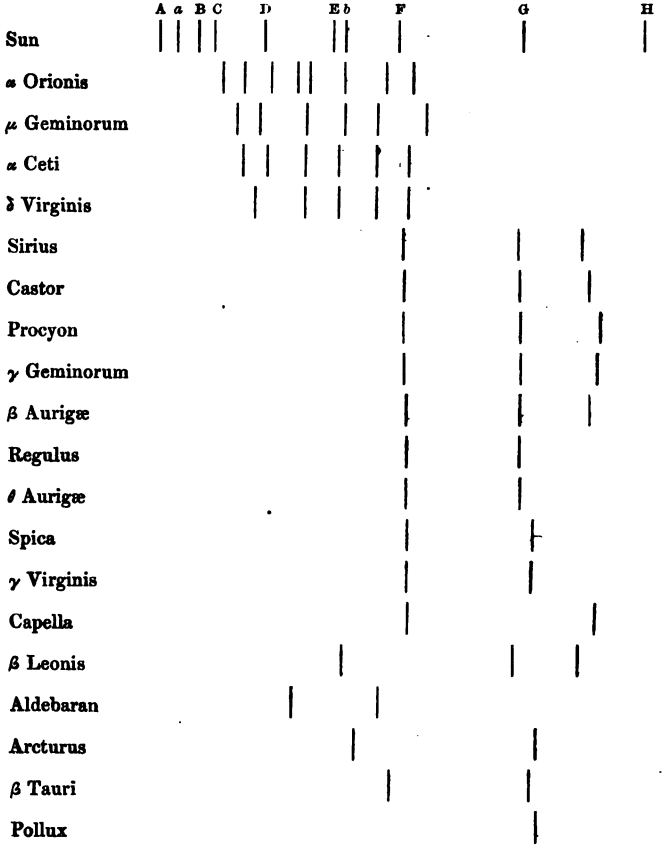
This principle may be regarded at present as experimental. In simplicity of construction it is much superior to the principle of causing the pencils which pass through the prism to consist of parallel rays, which requires the use of two achromatic object-glasses and one cylindrical lens; but it is not yet certain whether or not it defines the spectral lines with equal sharpness.

It is necessary now to explain how reference is made to the lines of the solar spectrum. In fig. 1, near the right-hand extremity of the large tube, a small circle may be seen. This is a view (not properly in section) of a small socket, which in fig. 3, lower side, may be seen empty; and which in fig. 2 contains a small eye-piece. It is thus used. A tube, containing at its end a very small hole (possibly $\frac{1}{500}$ inch in diameter) is thrust, in a definite position, into the right-hand tube of fig. 1, till the small hole is in the focal plane of the telescope-image. In this state the telescope is turned to the sun; the small hole represents a star of solar matter; and its spectrum may be observed and measured. An eyepiece with diagonal reflector, and carrying a wire in its focus, is thrust into the small socket, as in fig. 2, and the position of the solar hole with

reference to the wire is carefully observed. Then, when a star is to be observed, the small eyepiece is thrust in, the telescope is moved till the star's image has the same position in regard to the wire which the solar hole had, and then it is certain that the star occupies precisely the place of the solar hole; then the small eyepiece is withdrawn, and the spectrum is observed and measures are made with the micrometer.

For reading the comb of the micrometer there is an annular reflector to illuminate the field, not shown in the drawing.

The following sketch exhibits lines whose positions have been measured by Mr. Carpenter; numerous lines have been seen but not measured.




On this sketch Mr. Carpenter remarks:—

*This diagram* is only intended to show the positions of the

lines; no attempt has been made to illustrate their characters or their different intensities. The stellar lines are generally nebulous, resembling the solar line H; in the first four stars on the diagram they are, however, much more diffused on the side opposite to the red end of the spectrum.

Since these observations were communicated to the Society two more lines have been detected in the spectrum of *Arcturus;* one coincident with solar D, the other between it and solar C.

G. B. A.

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*Lines in the Solar Spectrum, as observed in the Balloon Ascent, 31st March last.* By J. Glaisher, Esq. F.R.S.

The Astronomer Royal lent me the same apparatus as was used by Professor Smyth on the Peak of Teneriffe, for the purpose of observing the black lines in the spectrum. It consists of a prism, a fine adjustable slit placed in the focus of an object-glass of 14 inches focal length, and a telescope of the same length directed to the prism. No angular measure was contemplated, only eye observations and comparison of differences in the spectrum seen on the earth and at different distances from it in the course of the journey.

On the earth before leaving, a careful examination of the sky spectrum showed B as the limit of the red end, and some distance beyond G as that of the violet end, and all the principal lines.

The balloon left the earth on March 31, at a quarter past four P.M. At the height of half-a-mile the spectrum showed a general correspondence with that seen before starting, but I thought that G was less distinct and B was certainly less so.

At the height of a mile the spectrum was bright, but was shorter both at the red and violet ends, G was quite the limit, B was not visible, and C was doubtful.

At the height of two miles G was entirely lost, I could see F and D, but not beyond.

At the height of three miles the spectrum was very short, I could see a little beyond D to E, F was quite lost.

At the height of four miles I could see a little yellow tinge, but no lines.

At the height of four and a half miles I had no spectrum at all, even with a very open slit.

All those spectra were from the sky at an elevation of 60°; as far as time permitted I looked at a horizontal spectrum, and I did not see any marked difference between it and the spectrum at the higher elevation, at the same time. The general results

of these experiments are, that no line was lost from the spectrum, except through the loss of the spectrum itself, and that the spectrum shortened with increase of elevation.

The shortening of the spectrum with increase of elevation may have been, and most likely was, owing to want of light, (although to my senses there was abundance), the sky was of a deep dark blue, the sun was low, and it is possible the light was insufficient. For this class of observations it will be necessary to have a morning or mid-day ascent, for comparison of results with the preceding as well as to determine whether really the spectrum shortens with elevation or not.

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## *Results of the Meridional Observations of Small Planets; Occultations of Stars by the Moon; and Phenomena of Jupiter's Satellites; observed at the Royal Observatory, Greenwich, in the months of February and March,* 1863.

(*Communicated by the Astronomer Royal.*)

### *Astræa* (5).

| Mean Solar Time of Observation. | R.A. from Observation. | N.P.D. from Observation. |
|---|---|---|
| | h m s | h m s |
| 1863, Feb. 3 | 13 23 41·3 | 10 18 33·47 | 78 57 20·09 |
| 12 | 12 41 48·1 | 10 12 2·42 | 77 44 56·16 |
| 13 | 12 37 5·1 | 10 11 15·20 | 77 36 35·35 |
| 16 | 12 22 53·7 | 10 8 51·07 | 77 11 32·87 |
| 21 | 11 59 11·7 | 10 4 48·03 | 76 30 14·05 |
| 27 | 11 30 55·5 | 10 0 6·47 | 75 43 7·56 |
| 28 | 11 26 15·0 | 9 59 21·72 | 75 35 41·74 |
| Mar. 3 | 11 12 19·1 | 9 57 13·25 | 75 14 10·08 |
| 4 | 11 7 42·5 | 9 56 32·37 | 75 7 17·41 |
| 11 | 10 36 1·6 | 9 52 22·20 | 74 24 7·20 |
| 16 | 10 14 8·0 | 9 50 7·74 | 73 59 2·40 |
| 17 | 10 9 50·2 | 9 49 45·77 | 73 54 41·46 |
| 21 | 9 52 57·5 | 9 48 36·48 | 73 39 18·79 |
| 23 | 9 44 42·1 | 9 48 12·83 | 73 32 56·47 |
| 24 | 9 40 37·0 | 9 48 3·63 | 73 30 6·51 |
| 25 | 9 36 34·1 | 9 47 56·65 | 73 27 27·25 |
| 26 | 9 32 32·8 | 9 47 51·26 | 73 25 0·76 |
| 27 | 9 28 33·7 | 9 47 48·07 | 73 22 49·03 |
| 31 | 9 12 55·6 | 9 47 53·61 | 73 16 6·62 |

## *Victoria* (15).

| Mean Solar Time of Observation. | | R.A. from Observation. | N.P.D. from Observation. |
|---|---|---|---|
| | h m s | h m s | ° ′ ″ |
| 1863, Feb. 13 | 11 37 22·5 | 9 11 22·76 | 87 12 36·29 |
| 16 | 11 22 41·0 | 9 8 28·53 | 86 57 52·78 |
| 17 | 11 17 48·3 | 9 7 31·56 | 86 52 43·48 |
| 28 | 10 24 59·3 | 8 57 55·96 | 85 53 2·85 |
| Mar. 3 | 10 10 57·2 | 8 55 41·27 | 85 36 17·41 |
| 17 | 9 8 8·4 | 8 47 53·81 | 84 20 40·25 |
| 21 | 8 51 6·2 | 8 46 35·02 | 84 1 4·52 |

## *Irene* (14).

| Mean Solar Time of Observation. | | R.A. from Observation. | N.P.D. from Observation. |
|---|---|---|---|
| | h m s | h m s | ° ′ ″ |
| 1863, Feb. 12 | 13 29 29·6 | 10 59 51·76 | 67 36 19·84 |
| 13 | 13 24 52·2 | 10 59 10·11 | 67 27 13·42 |
| 14 | 13 20 13·6 | 10 58 27·32 | 67 18 10·24 |
| 16 | 13 10 52·7 | 10 56 57·95 | 67 0 18·92 |
| 17 | 13 6 10·7 | 10 56 11·76 | 66 51 32·73 |
| 28 | 12 13 38·3 | 10 46 52·86 | 65 26 2·62 |
| Mar. 3 | 11 59 12·6 | 10 44 14·40 | 65 7 17·03 |
| 4 | 11 54 24·2 | 10 43 21·80 | 65 1 32·69 |
| 17 | 10 52 52·5 | 10 32 55·12 | 64 13 35·83 |
| 21 | 10 34 33·2 | 10 30 19·08 | 64 9 20·45 |
| 23 | 10 25 32·8 | 10 29 10·25 | 64 9 1·52 |
| 24 | 10 21 4·8 | 10 28 38·11 | 64 9 20·63 |
| 25 | 10 16 38·9 | 10 28 8·04 | 64 9 57·18 |
| 26 | 10 12 14·5 | 10 27 39·47 | 64 10 51·05 |
| 27 | 10 7 51·8 | 10 27 12·60 | 64 12 2·57 |
| 31 | 9 50 39·6 | 10 25 43·74 | 64 19 39·93 |

## *Urania* (30).

| Mean Solar Time of Observation. | | R.A. from Observation. | N.P.D. from Observation. |
|---|---|---|---|
| | h m s | h m s | ° ′ ″ |
| 1863, Feb. 5 | 8 9 48·4 | 5 11 42·11 | 65 36 22·02 |

## *Ariadne* (43).

| Mean Solar Time of Observation. | | R.A. from Observation. | N.P.D. from Observation. |
|---|---|---|---|
| | h m s | h m s | ° ′ ″ |
| 1863, Feb. 14 | 10 48 27·4 | 8 26 16·21 | 75 7 34·27 |
| 17 | 10 33 49·5 | 8 23 25·59 | 74 58 8·07 |
| 18 | 9 42 4·7 | 8 14 54·32 | 74 27 39·58 |

## *Bellona* (35).

| Mean Solar Time of Observation. | R.A. from Observation. | N.P.D. from Observation. |
|---|---|---|
| h m s | h m s | ° ′ ″ |
| 1863, Feb. 3 12 29 22·6 | 9 24 5·86 | 76 53 46·05 |
| 12 11 46 46·2 | 9 16 51·42 | 75 34 43·19 |
| 13 11 42 2·7 | 9 16 3·78 | 75 26 1·69 |
| 14 11 37 20·0 | 9 15 16·81 | 75 17 20·50 |
| 16 11 27 55·9 | 9 13 44·24 | 75 0 13·22 |
| 17 11 23 15·2 | 9 12 59·34 | 74 51 45·05 |
| 21 11 4 39·4 | 9 10 6·77 | 74 18 46·00 |
| 27 10 37 17·3 | 9 6 19·39 | 73 32 34·51 |
| 28 10 32 47·5 | 9 5 45·45 | 73 25 22·98 |
| Mar. 2 10 23 53·4 | 9 4 42·97 | 73 11 20·49 |
| 3 10 19 28·9 | 9 4 14·34 | 73 4 33·56 |
| 4 10 15 4·6 | 9 3 45·84 | 72 57 57·15 |
| 17 9 20 23·8 | 9 0 11·22 | 71 46 54·03 |
| 21 9 4 32·5 | 9 0 3·55 | 71 30 59·42 |
| 23 8 56 47·2 | 9 0 10·14 | 71 24 7·74 |
| 24 8 52 57·3 | 9 0 16·08 | 71 20 55·13 |
| 25 8 49 9·2 | 9 0 23·92 | 71 17 55·65 |
| 26 8 45 22·3 | 9 0 33·00 | 71 15 0·49 |
| 27 8 41 37·8 | 9 0 44·41 | 71 12 25·96 |
| 31 8 26 55·2 | 9 1 45·65 | 71 3 29·85 |

## *Europa* (52).

| Mean Solar Time of Observation. | R.A. from Observation. | N.P.D. from Observation. |
|---|---|---|
| h m s | h m s | ° ′ ″ |
| 1863, Feb. 3 10 4 41·3 | 6 59 0·82 | 70 13 4·54 |
| 9 9 38 14·0 | 6 56 8·47 | 69 50 33·65 |
| 11 9 29 36·9 | 6 55 23·03 | 69 43 28·00 |
| 13 9 21 5·6 | 6 54 43·51 | 69 36 30·49 |
| 14 9 16 52·4 | 6 54 26·17 | 69 33 5·47 |
| 16 9 8 30·7 | 6 53 56·13 | 69 26 27·75 |

## *Diana* (78).

| Mean Solar Time of Observation. | R.A. from Observation. | N.P.D. from Observation. |
|---|---|---|
| h m s | h m s | ° ′ ″ |
| 1863, Mar. 27 11 29 23·7 | 11 48 57·86 | 96 56 25·75 |
| 31 11 10 0·4 | 11 45 17·59 | 96 46 33·45 |

All the observations of N.P.D. have been corrected for Refraction and *Parallax.*

### *Occultations of Stars by the Moon.*

| Day of Observation. 1863. | Phenomenon. | Moon's Limb. | Mean Solar Time. h m s | Observer. |
|---|---|---|---|---|
| Feb. 11 | 15 Geminorum, disapp. | Dark | 9 43 15·8 | S. |
| Mar. 2 | $\alpha$ Cancri, disapp. | Dark | 11 48 54·8 | C. |

The star, the occultation of which was observed on Jan. 27, and printed without a name in the last number of the *Monthly Notices*, page 174, was $\delta$ *Arietis*.

### *Phenomena of Jupiter's Satellites.*

| Day of Observation. 1863. | Satellite. | Phenomenon. | Mean Solar Time. h m s | Observer. |
|---|---|---|---|---|
| Feb. 16 | I | Eclipse, disapp. | 14 2 27·1 | E. |
| 17 | I | Ingress, first cont. | 12 3 35·7 | R. |
| ,, | I | ,, bisection | 12 6 35·2 | R. |
| ,, | I | ,, total ingress | 12 10 34·6 | R. |
| ,, | I | Egress, first cont. | 14 14 42·9 | R. |
| ,, | I | ,, bisection | 14 18 42·3 | R. |
| ,, | I | ,, last cont. | 14 21 26·8 | R. |
| Feb. 28 | II | Eclipse, disapp. | 12 42 6·2 | E. |
| Mar. 11 | I | Eclipse, disapp. | 14 10 32·1 | D. |
| 25 | II | ($a$) Eclipse, disapp. | 9 43 25·3 | C. |
| ,, | II | Occ. reapp. bisection | 12 59 40·7 | C. |
| ,, | II | ,, last cont. | 13 0 55·5 | C. |
| 26 | III | Eclipse, disapp. | 13 20 57·1 | J. C. |
| 27 | I | Eclipse, disapp. | 12 25 34·9 | D. |

($a$) The satellite extremely faint, the observation very unsatisfactory.

The initials S., D., E., C., J. C., and R., are respectively those of Mr. Stone, Mr. Dunkin, Mr. Ellis, Mr. Criswick, Mr. Carpenter, and Mr. Roberts.

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### *Note on the Appearance of the Dark Ring of Saturn.*
By J. Carpenter, Esq.

During the observation of *Saturn* with the transit-circle, on the evening of March 26th, 1863, it struck me that the dark space between the ring and the ball seemed much contracted. Upon looking at it with the Equatoreal I found that this arose from a great increase in the brightness of the dusky ring, which appeared nearly as bright as the illuminated ring, and might easily have been mistaken for a part of it.

*Occultation of* B.A.C. 4006 *by the Moon, observed at Forest Lodge, Maresfield, by Capt. W. Noble, on Thursday, April 2, 1863.*

The star disappeared at

$12^h\ 9^m\ 46^s{\cdot}6$ L.S.T. $= 11^h\ 26^m\ 33^s{\cdot}62$ L.M.T.

Owing to the obliquity of the Moon's motion over it, and the immersion taking place near a high mountain, the star presented the appearance of a little sun setting; its spurious disc apparently descending and touching the lunar limb, just before its instantaneous disappearance. The reappearance was not observed.

Telescope employed: my Ross Equatoreal of 4·2 inches aperture, with a power of 255 adjusted on the star.

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## *Note on a Small Companion of Procyon, &c.*

By J. Gurney Barclay, Esq.

Towards the close of December, 1855, my attention was directed to the neighbourhood of *Procyon*, by a letter to the Editor of the *Times* from Mr. Hind, dated 21st of that month, in which he stated, that he strongly suspected the existence of some star or other body in the immediate neighbourhood of *Procyon*, by which the proper motion of that star was irregularly affected.

Being at that time in possession of an excellent Refractor, by Cooke, of $7\frac{1}{2}$ inches aperture, I took the earliest opportunity of closely inspecting the neighbourhood of *Procyon*, and on the 10th January, 1856, I discovered a small star within the blaze of the light of the larger one, and which I roughly estimated at from 3 to 4 seconds of time by the sound of the clock preceding *Procyon* in R.A., and but little removed to the North in December.

I communicated these particulars to Mr. Hind, accompanying them with a rough sketch of the relative position of the small star with the large one, and two others of small magnitude in the immediate vicinity. Mr. Hind having recently again called my attention to this object, I requested Mr. Romberg, who has the care of my Observatory, and which now contains a 10-inch Refractor by the same maker, to give it his best attention, and to endeavour to determine with some accuracy the exact position of the small star. This he has done, and given the result in the accompanying paper. I may add, that in order to get a very distinct view of the object, we *found it* necessary to make use of a ring micrometer, by which

the rays of light of the large star were shut off, by being brought behind the dark ring.

The other two minute stars which he notices, are clearly fainter than that above described, but are distinctly visible with the 10-inch aperture in the absence of the large star from the field.

Mr. Romberg has also given his attention to the measurement of the triple star of *γ Andromedæ*, and has succeeded in obtaining some satisfactory results.

*Leyton, Essex,*
*24th March*, 1863.

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## *Measures of the Small Star near Procyon.*
By Hermann Romberg.

I determined the position of this small star, which was first seen by Mr. Gurney Barclay in the year 1856, in reference to *Procyon*.

| | | | | | | |
|---|---|---|---|---|---|---|
| | 1863, March 17 | 295° 18′ | (6) | | | |
| | 18 | 295 40 | (6) | | | |
| | 19 | 294 25·5 | (6) | 44″·9 | (12) | |
| | 21 | 294 14·1 | (6) | | | |
| | 23 | 294 47·5 | (6) | 46·9 | (9) | |
| Mean | 1863·22 | 294 54 | (30) | 45·8 | (21) | |

I estimate the small star to be of the 10.5 magnitude.

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## *Measures of the Companion of γ Andromedæ.*
By Hermann Romberg.

I attacked this star with Mr. G. Barclay's excellent Refractor, during the winter, on several occasions, but was never very successful; but since the 17th of February, shortly after sunset, the star was shown clearly divided every time I looked at it with powers 750, 500, and 330. By means of a roughly introduced spider's line I obtained the following measures of position: —

| | | | |
|---|---|---|---|
| | 1863, Feb. 27 | 107° 41′ | (12) |
| | Mar. 18 | 105 43 | (6) |
| | 19 | 107 10 | (4) |
| Mean | 1863·20 | 107 3 | (22) |

I estimated the distance to be about 0″·6, and the magnitudes of the stars 5 and 6.5.

*Mr. Gurney Barclay's Observatory,*
*Leyton, 1863, April 7.*

## *Observations and Elements of Comet I.* 1863.
By Hermann Romberg.

I have obtained the following observations of the Comet I., 1863 :—

| | M.G.T. | Δα Comet − Star. | Δδ Comet − Star. | |
|---|---|---|---|---|
| | h m s | m s | ′ ″ | |
| 1863, Jan. 11 | 15 55 59·5 | +9 15·230 | +5 13·5 | *a* |
| 20 | 17 51 59·4 | 0 41·951 | +7 9·4 | *b* |
| 24 | 17 58 35·5 | 1 36·834 | +4 54·3 | *c* |
| Feb. 3 | 16 59 16·0 | 0 17·832 | −4 30·0 | *d* |
| | 17 39 9·5 | +0 22·540 | −5 18·1 | *d* |

The apparent places of the stars of comparison for the date of observation are,

| | h m s | ° ′ ″ | |
|---|---|---|---|
| (*a*) | 17 41 19·20 | +38 56 8·5 | Radcl. |
| (*b*) | 19 16 28 | 34 2 0 | Lal. |
| (*c*) | 19 38 21·41 | 31 45 11·7 | B. Z. |
| (*d*) | 20 17 5·88 | +26 41 30·8 | B. Z. |

The star (*b*) is given in Argelander's Northern Zones, Zon. +34°.

On Feb. 3d I compared the Comet with another star, and obtained, for the above times,

| | | m s | ′ ″ |
|---|---|---|---|
| Feb. 3 | | −1 34·568 | −3 20·2 |
| | | −1 29·660 | 4 11·1 |
| | 18h 22m 5c·0 | −1 24·547 | −5 6·1 |

The apparent place of this latter star is nearly

20h 18m 28s·19 +26° 40′ 22″·3

The differences in Right Ascension and Declination are corrected for Refraction and Parallax; they are the means of at least six transits. The Comet's appearance was round and faint; but I discerned from the 20th of February a faint *nucleus,* which had on the 3d of February increased consider-

ably in brightness. Unfavourable weather in the morning hours prevented me from observing it any further.

I calculated the following parabolic elements from the observations, Berl., Dec. 5, Dec. 26, Leyton, Jan. 11, taking into the account the corrections of Aberration and Parallax:—

| | | |
|---|---|---|
| T | 1863, Feb. 3·48790 M.G.T. | |
| $\pi$ | 191 22 12·4 | Mean Eq. 1863·0 |
| $\Omega$ | 116 55 19·7 | |
| $i$ | 85 21 34·2 | |
| log $q$ | 9·9002614 | |
| | Direct. | |

These elements give for the mean place the error

C − O $\quad \Delta\alpha = -0''\cdot7 \quad \Delta\delta = +7''\cdot1$

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*On a mode of Figuring Glass Specula for the Newtonian Telescope.* By the Rev. Henry Cooper Key.

As the subject of silvered glass specula is now beginning to attract some attention, I have taken the liberty of laying before the Society a brief account of the successful manufacture of these specula, including a method which I have suggested for producing with great ease and certainty the true parabolic figure necessary for first-rate performance.

The machine used for the purpose is the same in principle as that of the Earl of Rosse, and very similar in detail, but with some slight modification in the speed of the various parts. The number of strokes to one revolution of the speculum-plate is 104. The pin of the eccentric giving the side motion is carried from side to side with an unequal velocity by means of an oval wheel, whereby the centre is passed over rapidly and the action is prolonged at the two extremes. The number of revolutions of the side-motion eccentric to one revolution of the speculum-wheel is $5\frac{1}{2}$. The amounts of stroke and side-motion found to produce the best results are stroke = $\frac{1}{3}$ diameter of the speculum and side-motion $\frac{1}{4}$ the same; but precision on this point does not appear to be very material.

The glass disc is ground upon a cast-iron tool, of the same diameter as itself, carefully turned to the guage, and scored at right-angles into facets $\frac{1}{8}$-in. square; these grooves are filled up with wax or pitch until the rough grinding is complete, or nearly so. It is not absolutely necessary to work a concave iron tool upon the convex, the simplest plan being to figure

the convex tool by means of the speculum itself; or, if more than one is to be worked, by grinding them alternately upon it. The convex tool should be turned to a curve giving about 6 inches less focal length than that ultimately desired, to allow for the lengthening that will take place in the course of the grinding.

The fine grinding is effected by means of emery of six different degrees of fineness, commencing with flour-emery No. 1; these are, of course, obtained by washing and pouring off the finer particles while in suspension. The sixth, finest quality, takes between two and three days to settle. The last application is slate-mud, carefully washed, and mixed with a very little rouge, also washed. Rouge always contains some amount of grit, and should never be used unwashed.

As the character of the spherical figure, upon which the quality of the future mirror entirely depends, is given in fine grinding upon the iron tool, it is advisable to prolong the process of fine grinding considerably, and to bring the surface in fact, to such a fine degree of semi-polish, that, when placed with wet rouge on the pitch-tool, it shall come up to a perfect polish in from three to four hours. The shorter the sojourn of the speculum on the pitch-tool the better. I need scarcely add that no rings of unequal polish ought to appear during any part of the fine grinding.

The pitch polishing tool may be made either of two pieces of seasoned wood glued together across the grain, or of slate. It should be turned to the guage, and, as it should be of the same size as the speculum when coated with pitch, it must be about $1\frac{1}{2}$ inches larger in diameter, to allow of the margin being perfect. The pitch is hardened with resin, until the thumb-nail can make little or no impression upon it when cold: the harder it is the better, provided it be not too brittle. It is to be scored, while still warm, into squares or facets, which, after some hours' work upon the machine, shall not exceed $\frac{1}{2}$-in. square on the surface, and shall stand at least $\frac{3}{8}$-in. high, the base of each facet being not less than $\frac{7}{8}$-in. square. It is of great importance that they stand well detached from one another, that they may give equally to pressure in all directions. In polishing, as well as in grinding, the speculum is placed uppermost.

The speculum, when polished and placed in the tube, and directed to a fine watch-dial at about 100 yards' distance, will now show that the extreme marginal rays come to a focus about $\frac{1}{4}$-inch inside the central rays—proving thereby a spherical figure.

To give the parabolic figure, which shall unite all the rays in one precise focus, proceed with a sharp chisel to cut the facets of the pitch-tool smaller, leaving the four centre ones untouched, and gradually diminishing the surface of the others *over the* whole face of the tool, until those at the margin are

reduced to $\frac{1}{4}$-inch square, or even a little less. The proper amount of graduation is obtained by experience, and upon the judicious execution of this the quality of the speculum will depend. The speculum is now placed upon the graduated tool, and the action of the machine continued with the same amount of stroke and side-motion as before, until, supposing its surface divided by diaphragms into four nearly equal zones—outer, second, third, and central—it gives equally perfect definition on the dial, and bears an equally high power, with each zone, at precisely the same focal point. This is attained usually in a few hours, without any difficulty. I ought perhaps to add, by way of caution, that the stroke and side motion must not be altered in amount in the slightest degree from the commencement of the fine grinding to the completion of the figure, and more especially the side motion.

This is the normal mode of procedure; but, by way of precaution, it is advisable to graduate the pitch-tool very slightly before commencing the polishing; and when that is quite perfect (and not the slightest granulation must be left visible), the tool is to be fully graduated, as before stated.

My first experiment with the graduated tool, when the idea occurred to me, was made on a half-polished mirror, and in two and a half hours the definition became such as to surprise me. With a half-polished mirror, unsilvered, 12-inches aperture and power of 1000, the dial was exquisitely defined; with 350 the effect was that of viewing the dial itself close to the eye without the intervention of a telescope; and a fly resting on the well-focussed dial remained itself out of focus, with the exception of its feet, forcibly reminding me of the definite focal plane of a good achromatic microscope: the mirror, in fact, came up to focus and went out—in an instant—with the sharp precision of a microscope.

No more severe test is required, or indeed can be found, to insure fine performance on celestial objects, than the dial, and the mode of procedure above mentioned.

The speculum is to be silvered by Liebig's process; and the coat should be rather thin, as, if thick, it is liable to lose its fine figure by rubbing up. The silver will never tarnish if kept dry. A small bag should be kept in the same box with it, containing sawdust which has been saturated with chloride of calcium, and dried.

Circumstances over which I had no control have prevented my own further progress, and, indeed, I shall be delayed some weeks longer before I am able to resume the work; but having, last autumn, communicated my method to Dr. Frankland, of the Royal Institution, and to Mr. With, Master of the Bluecoat School at Hereford, I am able to state what they have accomplished.

Dr. Frankland immediately and readily figured a speculum of 7 inches' aperture, whose spherical figure was not good (it

having been polished by hand on paper), so that it would split 36 *Andromedæ* with 210, clearly and sharply. He, however, expects superior results from a machine-made speculum, and speaks in the highest terms of my suggestion of the graduated pitch-tool.

Mr. With, of Hereford, in his small intervals of leisure during the last three months, has completed three or four glass specula of the highest class, $6\frac{1}{4}$-inches aperture and 6-feet focus, and $5\frac{1}{2}$-inches aperture and $4\frac{1}{2}$-feet focus. With the larger telescope he is able to elongate the disk of the small companion of *γ Andromedæ* readily. Its definition of a large fixed star is remarkably fine, giving a perfectly round clean disk, surrounded at a little distance by one faint concentric ring, and without any other appendage or false light whatever.* This was his first attempt. One of his $5\frac{1}{2}$-inches specula is, however, slightly superior to this, and is presumed to be perfect: not the least trace of error of figure can be detected over the entire surface after the strictest scrutiny.

The belief is, after sundry trials and comparisons with achromatics, that the silvered-specula Newtonian is very little, if at all, inferior in efficiency to the finest achromatic of the same aperture. Should this be confirmed by future experience, as I fully anticipate it will be, the former will prove to be formidable rivals to the latter, as the cost of making is not likely to amount to one-eighth or even one-tenth of the achromatic object-glass.

I have omitted to mention that excellent small glass flats for silvering may be obtained from the common French plate-glass—the best from the middle of the plate.

Should any member of the Society desire further information beyond what I have been able to convey in these brief notes, I shall be happy to give it at any time.

*Stretton Rectory, Hereford,*
*March 9th*, 1863.

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## *Companion of Sirius.*

(*Extract of a Letter from the Rev. W. Dawes.*)

"Goldschmidt's star *d* near *Sirius* is easy enough, but I have not been able to perceive any of the others. In fact, such

* The fifth star in the trapezium in *Orion* is visible as a steady object, and the sixth in moments of fine vision. The distant comes of λ *Orionis*, not mentioned by Smyth, is an easier object in this telescope than the fifth star in the trapezium. In the triple star ζ *Orionis* the separation between the *close pair* is equal to one diameter of the large star with a power of 220.

an object is far less a *telescopic*, than an *atmospheric test* in these latitudes. The star should be examined at the Cape of Good Hope."

*Hopefield, Haddenham, 10th April, 1863.*

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Mr. Carrington, in reference to the subject of the Motion of the Solar System in Space, remarks as follows:—

"I have just become acquainted with the circumstance, that in 1859 a Royal Medal was offered for competition in the University of Christiania for the best Memoir to be received in 1860, containing an investigation whether the mean direction of motion of the Comets before coming under solar influence differed from the concluded motion of the Sun, and that the award was made to Candidate Mohn for a Memoir just published under the professorial superintendence of Prof. Fearnley. Very curiously, as it appears to me, the attack is conducted by the only way which I can conceive different to the process I followed myself in 1860, in a short Memoir which the Society did me the honour to publish. Mr. Mohn, after selecting 173 orbits, and throwing out the periodical ones, searches to find whether there is any region of the heavens approaching a great circle belt, in which the poles of the several planes of motion are chiefly congregated, and finding such a belt of preponderance and fairly regular distribution, points out that the axis of this belt will be the general direction of cometic motion as defined. His conclusion is, that the direct and retrograde Comets concur in giving a mean direction of motion towards long. 0° lat. + 10½°, or nearly at right angles to the general conclusion for solar motion.

"But Prof. Fearnley, who appears, as proposer of the Problem in Christiania, to take much personal interest in it, points out in his commentary that the direction found in the Memoir is greatly attributable to the special circumstances attending the discovery of Comets, which, it will be remembered, I had also occasion to dwell upon in considering the conclusions of my own investigation. These are

"1 The discovery generally between sunset and midnight.

"2 Observers mainly in northern hemisphere.

"3 The heliocentric elongation of the Comet being commonly acute.

"He goes so far as to say, that examining the effects of these circumstances, he obtains, as a direct and necessary consequence therefrom, the result arrived at by Mr. Mohn.

"The attack on this problem by way of the orbits appears, therefore, *by two* independent inquiries, to be hopelessly

nugatory; and it becomes the more desirable that the older route of research should be promoted by the improving the data needful for its success, namely, well determined stellar residual motions; the whole subject at present seeming, on critical examination, to be less advanced than once supposed, though presenting hopes of successful future research."

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### *Minor Planet* (77).

The discovery of this minor planet by Dr. Peters, and his observations of it Nov. 1862, are mentioned *Monthly Notices*, *ante*, p. 76, and in the *Ast. Nach.* No. 1399. No further observations appear to have been made, nor any elements computed.

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### *Minor Planet* (78), *Diana.*

The discovery, by Dr. Luther, Director of the Observatory of Bilk, is announced *Ast. Nach.* No. 1408; the planet was seen of the magnitude 10, the position being

1863, March 15, $13^h\ 24^m\ 14^s{\cdot}4$ Bilk M.T. R.A. $180°\ 12'\ 6''{\cdot}8$.
Decl. $-7°\ 20'\ 3''{\cdot}4$.

the retrograde motion being more than 2 seconds of time in the hour.

The following elements, calculated from the Bilk Observation of 15 March, and from observations at Bonn, March 23 and 31, have been calculated by Herr Tiele of Bonn, *Ast. Nach.* No. 1410.

Epoch, 1863, March 15·0, Berlin M.T.

| | | | | | |
|---|---|---|---|---|---|
| M | = | 39 | 50 | 29·0 | |
| $\pi$ | = | 121 | 6 | 30·3 | Equinox, 1863·0. |
| $\Omega$ | = | 334 | 1 | 19·3 | |
| $i$ | = | 8 | 39 | 4·8 | |
| $\varphi$ | = | 11 | 59 | 38·8 | |
| $\mu$ | = | 833″·877 | | | |
| Log $a$ | = | 0·419270 | | | |

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## RECENT PUBLICATIONS.

*Untersuchungen über veränderliche Eigenbewegungen von G. F. J. Arthur Auwers. Erster Theil: Bestimmung der Elemente der Procyonbahn und Untersuchung der für veränderlich gehaltenen Eigenbewegungen von α Virginis, β Orionis und α Hydræ. Nebst einem die Reduction eines Theils der Beobachtungen an den Mittagsfernröhren von Greenwich und Palermo von 1765 bis 1810 enthaltenden Anhang. Inaugural Dissertation.* 4°, Königsberg, 1862, pp. 1–96.

The researches on Procyon, *Ast. Nach.* Nos. 1371 73 (an abstract of which is published, *Monthly Notices, ante*, pp. 18–20), are, in fact, an extract from this elaborate memoir; the title shows what are the other stars to which M. Auwers has extended his investigations.

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For Sale: A Marine Box Chronometer, the property of Mr. Carrington. Price 18*l.* It was cleaned and put in thorough order last year, and may be seen, and its rates inspected, at Mr. Frodsham's, in the Strand, where it has since remained, from the owner having no further use for it.

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### ERRATA

*In No. 5 of the Monthly Notices, Vol. XXIII.*

Page 165 (heading), *for* Latitude, *read* Longitude.

— —, lines 1 and 2, *for* Kingston, *read* Kingstown.

— —, line 28, *for* R. J. Leckie, *read* R. J. Lecky, Esq.

— 166, — 22, *for* Knightstown, *read* Kingstown.

— 167, — 20, *for* apparent movements of the bodies in space, *read* apparent movements on the surface of a globe to the real movements of the bodies in space.

— 168, — 11, *for* 524°·54, *read* 514°·54.

— —, — 17, *for* 15° 31′, *read* 15°·31.

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# MONTHLY NOTICES

OF THE

# ROYAL ASTRONOMICAL SOCIETY.

VOL. XXIII. *May* 8, 1863. No. 7.


G. B. AIRY, Esq., Astronomer Royal, in the Chair.

Henry Johnson, Esq., 39 Crutched Friars;
Celestin Baume, Esq., Baume Lodge, East Brixton; and
Lieut. Geo. Lyon Tupman, Royal Marine Artillery,
were balloted for and duly elected Fellows of the Society.

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*On Solar Spots, and on the Variable Star η (Argo) Navis.* By Prof. Wolf.

(*Translation of part of a Letter to the Astronomer Royal, dated Zurich, 1863, April 2.*)

"In a short time I shall have the honour to lay before you the fifteenth number of my communications concerning the Solar Spots. At present I give you its principal contents, and I shall be much rejoiced if you consider this sufficiently interesting to be communicated to the Royal Astronomical Society. In the first place, I have determined, by means of my own observations, together with those of Herr Schwabe at Dessau, and Herr Jenzer at Berne, the mean relative number for the year 1862, and I have now for

| 1858 | 1859 | 1860 | 1861 | 1862 |
|---|---|---|---|---|
| 50·9 | 96·4 | 98·6 | 77·4 | 59·4 |

the relative numbers

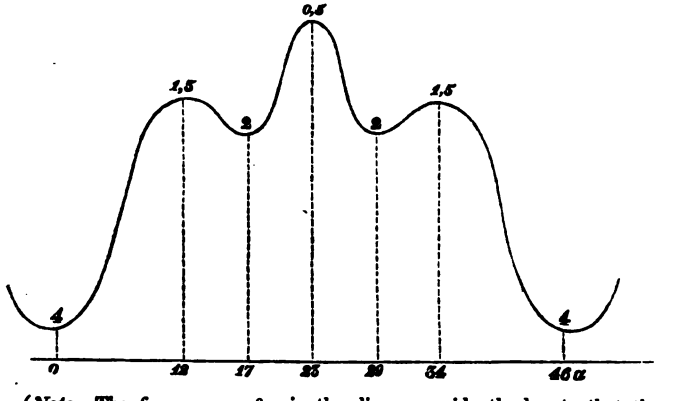
so that the Maximum which I had determined for 1860·2 is already very beautifully shown in these numbers. From the number, 59·4, corresponding to 1862, I have obtained, according to the formulæ laid down by me, for the year 1862, for Munich 9′·27, and for Prague 8′·38, as the mean declination variation. In the second place, I have not to enter here into some additions to the collection of formulæ in No. 13, in conjunction with one of my colleagues, Herr Fritz, made a new comparison between the phenomena of the Solar Spots and of the Northern Lights, which has yielded very interesting results. That is to say, evidence is afforded by it that the two phenomena form parallel curves, and not only does the *eleven-year period* show itself in the Aurora, but also the *greater period of about* 56 *years*, which I have referred to in No. 12 as becoming apparent in the case of the Solar Spots. By this labour, therefore, the secular period of the Aurora Borealis is at the same time established—a point on which no satisfactory conclusion has hitherto been arrived at.

"Besides these labours on the phenomena of the Solar Spots, I have recently obtained, when occupying myself with the Variable Stars, and having collected amongst others the observations of $\eta$ (*Argo*) *Navis*, a result which may be interesting to the Astronomical Society, and especially to Sir John Herschel. I found, contrary to the hitherto generally supposed irregularity, that a period of about 46 years could be attributed to it, as soon as two consecutive Maxima and Minima had been inserted, as the annexed light-curve indicates. There is, as it appears to me, nothing opposed to this in regard to $\beta$ *Lyræ* and R *Sagittæ*, and the observations with which I am acquainted are quite regularly represented thereby, as is shown by the following comparison:—

| | Hypothesis. | | Observation. | | |
|---|---|---|---|---|---|
| Phase. | Magnitude. | Time. | Time. | Magnitude. | Observer. |
| Minim. | 4 | 1677 | 1677 | 4 | Halley. |
| Minim. | 4 | 1723 | | | |
| Cons. Max. | 1·5 | 1735 | | | |
| Cons. Min. | 2 | 1740 | | | |
| Maxim. | 0·5 | 1746 | 1751 | 2 | Lacaille. |
| Cons. Min. | 2 | 1752 | | | |
| Cons. Max. | 1·5 | 1757 | | | |
| Minim. | 4 | 1769 | | | |
| : | | | | | |
| Minim. | 4 | 1815 | 1815 | 4 | Burchell. |
| | | | 1824 | 2 | Brisbane. |
| Cons. Max. | 1·5 | 1827 | 1827 | 1·5 | Burchell. |
| Cons. Min. | 2 | 1832 | 1832 | 2 | Johnson. |
| | | | 1835 | 1·5 | Herschel. |

| | Hypothesis. | | Observation. | | |
|---|---|---|---|---|---|
| Phase. | Magnitude. | Time. | Time. | Magnitude. | Observer. |
| Maxim. | 0·5 | 1838 | 1838 | 0·5 | Herschel. |
| | | | 1842 | 1 | Maclear. |
| Cons. Min. | 2 | 1844 | | | |
| | | | 1845 | 1 | Jacob. |
| Cons. Max. | 1·5 | 1849 | | | |
| | | | 1850 | 1 | Gilliss. |
| | | | 1856 | 1·5 | Powell. |
| | | | 1859 | 3·1 | Ditto. |
| Minim. | 4 | 1861 | 1861 | 3·6 | Ditto. |

"Possibly there may exist other observations unknown to me, which may overthrow my system, but the trial of my hypothesis would be always worthy of attention."




(*Note.* The figures 4, 2, &c. in the diagram evidently denote that the star's brightness will at these times be of the 4th magnitude, 2d magnitude, &c.—G.B.A.)

The Notes of Phase, which have been printed "cons." (consecutive) are in the original "sec.," conceived to have the same meaning.

The descriptions of Phase evidently ought to be these,—

| | |
|---|---|
| Minimum. | Minimum. |
| Minimum. | 1st Max. |
| 1st Max. | 1st Min. |
| 1st Min. | Maximum. |
| Maximum. | 2d Min. |
| 2d Min. | 3d Max. |
| 3d Max. | Minimum. |
| Minimum. | |

*Note on the Coefficient of the Parallactic Equation in the Lunar Theory.* By E. J. Stone, Esq.

The literal expressions of the coefficient of Parallactic Equation, developed to the sixth power of the small quantities, are identical in the theories of Plana, Pontécoulant, and Lubbock: the numerical value deduced with the usually received values of the constants, amounts to $122''{\cdot}1$; if we increase the mean Solar Parallax by a thirtieth part, the coefficient becomes $126''{\cdot}2$; the value deduced by the Astronomer Royal from the Greenwich Lunar Reduction is $124''{\cdot}7$; the value, however, given by the Altazimuth Observation alone amounted to $125''{\cdot}5$. The Astronomer Royal remarks in his Memoir that the Altazimuth Observations possess the rare advantage of having been extended to portions of every lunation very near to the conjunction of Sun and Moon, and thereby of discriminating between the entangled effects of Parallactic Equation and Variation. It would appear, therefore, that the lunar theory, as developed by these gentlemen to the sixth power of $m$, would be brought nearer to observation by increasing the mean Solar Parallax by a thirtieth part, but that the improvement (unless we adopt the value of the coefficient of Parallactic Equation deduced from the Altazimuth Observations) is by no means of a marked character. The coefficient of Parallactic Equation, given by Professor Hansen, is $121''{\cdot}4$, but the method of development adopted by him does not allow of direct comparison between his value and that deduced by Mr. Airy. It would be a point of interest to determine whether Professor Hansen's theory would bear any considerable increase in the mean Solar Parallax.

1863, *May 7th.*

---

*On the Acceleration of the Mean Motion of the Moon.*

In the *Berichte der K. Sächs. Gesellschaft zu Leipzig*, 15 April, 1863, is contained a short paper by Prof. Hansen, "Einige Bemerkungen über die Säcular-änderung der mittleren Länge des Mondes." The value of the acceleration, as calculated by Adams and Delaunay, is considerably — nearly $6''$ — less than that employed in the author's Lunar Tables; such smaller value cannot, however (as he has shown, *Comptes Rendus*, t. l., 1860), represent the ancient eclipses; and assuming that it is the correct value of the acceleration arising from the change in the excentricity of the solar orbit, the deficiency must be accounted for by other causes. That which most naturally presents itself is a change in the length of the

sidereal day, or period of the Earth's rotation; and he remarks that Laplace's demonstration of the invariability of the sidereal day depends on the very assumption that the acceleration is *wholly* accounted for by the change of the excentricity of the solar orbit, and consequently must in the present question be put aside. He proceeds to show that the deficiency of 6″ in the acceleration would be accounted for by an alteration of the sidereal day by the almost infinitesimal increase of $0^{s}\cdot01197$ in the course of 2000 years; and he remarks that the same alteration would produce a secular alteration of about 1″·9, consequently a sensible effect in the mean longitude of *Mercury*, the motion of which planet, as shown by Leverrier, is not completely accounted for by existing theories. Would the supposition in question produce a better agreement of the theory of *Mercury* with observation? This question he considers so important, that he cannot help expressing the wish that it may be soon undertaken. But in the meantime it is remarkable that the value of acceleration, as obtained by the author, without the assumption of any such supplementary cause, should agree so well with the observations, and that the small changes in the values of the secular variations to which his latest calculations have led him should produce a still better agreement. He in fact finds that to the coefficients of the secular variations of his Lunar Tables there should be added

| | |
|---|---|
| for Mean Longitude | + 0″·365 |
| ,, Perigee | − 1·352 |
| ,, Node | − 0·464 |

and he concludes by stating the effect of these changes on the eclipses of Thales, Agathocles, Stiklastadt, and Ennius, and on two eclipses in the years 1567 and 1605 respectively.

---

*Note on Plana's Lunar Theory.* By A. Cayley, Esq.

I have been much surprised to find that there is an error of the order $m^2\gamma^4$, arising from the omission of a factor $(1+\gamma^2)^{-1}$, in the expression for $\frac{d^2\delta u}{dv^2}+\delta u$, as given by the equation (II)′ (*Théorie de la Lune*, t. i. p. 267), being the equations made use of in the theory for the determination of $\delta u$, the perturbation of the reciprocal of the radius vector. This error may probably be the cause of some of the discrepancies in the terms of the fourth and higher orders, between Plana's results and those of Pontécoulant and Delaunay.

Plana's equation (6) t. i., p. 260, is

$$\frac{d^2 \delta u}{dv^2} + \delta u = a R''$$

$$+ f(e,\gamma)\, Q' e \cos(cv - \int' w\, dv)$$

$$- \left\{ f(e,\gamma)\,(1+\gamma^2)\,(1+s_1^2)^{-\frac{3}{2}} - \frac{a\,(1+s^2)^{-\frac{3}{2}}}{a_1 \psi(e,\gamma)} \right\}$$

$$+ f(e,\gamma)\, P \gamma^2 (1+s_1^2)^{-\frac{3}{2}} \Theta,$$

if for shortness

$$\Theta = \tfrac{3}{8}\gamma^2 - \left(1 + \tfrac{1}{2}\gamma^2\right) \cos(2gv - 2\int \theta\, dv) + \tfrac{1}{8}\gamma^2 \cos(4gv - 4\int \theta\, dv).$$

R'' (p. 256) should be

$$R'' = \frac{1}{\sigma a_1 \psi(e,\gamma)} \frac{\Omega_2 - \frac{du}{dv}\frac{d\Omega}{u^2 dv} - \sigma (1+s^2)^{-\frac{3}{2}} 2\int U\, dv}{1 + 2\int U\, dv},$$

but, by an error which is implicitly corrected, the $\sigma$ which multiplies $(1+s^2)^{-\frac{3}{2}}\, 2 \int U\, dv$ is omitted. Hence the equation (6) becomes

$$(1 + 2\int U\, dv)\left(\frac{d^2 \delta u}{dv^2} + \delta u\right) =$$

$$\frac{a}{\sigma a_1 \psi(e,\gamma)} \left\{ \Omega_2 - \frac{du}{dv}\frac{d\Omega}{u^2 dv} - \sigma (1+s^2)^{-\frac{3}{2}} 2\int U\, dv \right\}$$

$$+ (1 + 2\int U\, dv) f(e,\gamma)\, Q' e \cos(cv - \int w\, dv)$$

$$- (1 + 2\int U\, dv) \left\{ f(e,\gamma)\,(1+\gamma^2)\,(1+s_1^2)^{-\frac{3}{2}} - \frac{a\,(1+s^2)^{-\frac{3}{2}}}{a_1 \psi(e,\gamma)} \right\}$$

$$+ (1 + 2\int U\, dv) f(e,\gamma)\, P \gamma^2 (1+s_1^2)^{-\frac{3}{2}} \Theta,$$

in which equation

$$\Omega_2 = \frac{d\Omega}{du} + \frac{s}{u}\frac{d\Omega}{ds}, \text{ pp. 26, 245,} \quad \frac{d\Omega}{u^2 dv} = \frac{\sigma a_1}{\lambda^{\frac{3}{2}} (1+\gamma^2)^{\frac{3}{2}}} U, \text{ p. 265,}$$

$$\psi(e,\gamma) = \lambda^{-\frac{3}{2}} (1+\gamma^2)^{-\frac{1}{2}}, f(e,\gamma) = \lambda^{\frac{3}{2}} (1+\gamma^2)^{\frac{1}{2}}, \text{ p. 261.}$$

But retaining for greater convenience the function $f(e, \gamma)$ in two of the terms, we have

$$(1 + 2\int U\,dv)\left(\frac{d^2\delta u}{dv^2} + \delta u\right) = \frac{a}{\sigma a_,}\lambda^{\frac{3}{2}}(1+\gamma^2)^{\frac{1}{2}}\left\{\frac{d\Omega}{du} + \frac{s}{u}\frac{d\Omega}{ds}\right.$$

$$\left. - \frac{\sigma a_,}{\lambda^{\frac{3}{2}}(1+\gamma^2)^{\frac{1}{2}}} U\frac{du}{dv} - \sigma(1+s^2)^{-\frac{3}{2}} 2\int U\,dv\right\}$$

$$+ (1 + 2\int U\,dv) f(e,\gamma)\, Q' e\cos(cv - \int w\,dv)$$

$$- (1 + 2\int U\,dv)\lambda^{\frac{3}{2}}(1+\gamma^2)^{\frac{1}{2}}\left\{(1+s_,^2)^{-\frac{3}{2}} - \frac{a}{a_,}(1+s^2)^{-\frac{3}{2}}\right\}$$

$$+ (1 + 2\int U\,dv) f(e,\gamma)\, P\gamma^2 (1+s_,^2)^{-\frac{3}{2}}\Theta$$

$$= \frac{a}{\sigma a_,}\lambda^{\frac{3}{2}}(1+\gamma^2)^{\frac{1}{2}}\left(\frac{d\Omega}{du} + \frac{s}{u}\frac{d\Omega}{ds}\right)$$

$$- a U\frac{du}{dv}$$

$$- \frac{a}{a_,}\lambda^{\frac{3}{2}}(1+\gamma^2)^{\frac{1}{2}}(1+s^2)^{-\frac{3}{2}} 2\int U\,dv$$

$$+ (1 + 2\int U\,dv) f(e,\gamma)\, Q' e\cos(cv - \int w\,dv)$$

$$- (1 + 2\int U\,dv)\lambda^{\frac{3}{2}}(1+\gamma^2)^{\frac{1}{2}}\left\{(1+s_,^2)^{-\frac{3}{2}} - \frac{a}{a_,}(1+s^2)^{-\frac{3}{2}}\right\}$$

$$+ (1 + 2\int U\,dv) f(e,\gamma)\, P\gamma^2 (1+s_,^2)^{-\frac{3}{2}}\Theta.$$

which is

$$= \frac{a}{\sigma a_,}\lambda^{\frac{3}{2}}(1+\gamma^2)^{\frac{1}{2}}\left(\frac{d\Omega}{du} + \frac{s}{u}\frac{d\Omega}{dv}\right)$$

$$- a U\frac{du}{dv}$$

$$- \frac{a}{a_,}\lambda^{\frac{3}{2}}(1+\gamma^2)^{\frac{1}{2}}(1+s^2)^{-\frac{3}{2}} 2\int U\,dv \text{ (destroyed by term } \textit{infrà})$$

$$+ (1 + 2\int U\,dv) f(e,\gamma)\, Q' e\cos(cv - \int w\,dv)$$

$$-\lambda^{\frac{3}{2}}(1+\gamma^2)^{\frac{1}{2}}\left\{(1+s_,^2)^{-\frac{3}{2}}-\frac{a}{a_,}(1+s^2)^{-\frac{3}{2}}\right\}$$

$$-\lambda^{\frac{3}{2}}(1+\gamma^2)^{\frac{1}{2}}(1+s_,^2)^{-\frac{3}{2}}\,2\int U\,dv$$

$$+\frac{a}{a_,}\lambda^{\frac{3}{2}}(1+\gamma^2)^{\frac{1}{2}}(1+s^2)^{-\frac{3}{2}}\,2\int U\,dv \text{ (destroyed by term } \textit{supra})$$

$$+(1+2\int U\,dv)\,f(e,\gamma)\,P\gamma^2(1+s_,^2)^{-\frac{3}{2}}\Theta;$$

or, putting $u=\frac{1}{a}(u_,+\delta u)$, this becomes

$$(1+2\int U\,dv)\left(\frac{d^2\delta u}{dv^2}+\delta u\right)$$

$$=\frac{a}{a_,}\lambda^{\frac{3}{2}}(1+\gamma^2)^{\frac{1}{2}}\left(\frac{d\Omega}{du}+\frac{s}{u}\frac{d\Omega}{dv}\right)$$

$$-U\left(\frac{du_,}{dv}+\frac{d\delta u}{dv}\right)$$

$$-\lambda^{\frac{3}{2}}(1+\gamma)^{\frac{1}{2}}(1+s_,^2)^{-\frac{3}{2}}\,2\int U\,dv$$

$$+(1+2\int U\,dv)\,f(e,\gamma)\,Q'e\cos(cv-\int w\,dv)$$

$$-\lambda^{\frac{3}{2}}(1+\gamma^2)^{\frac{1}{2}}\left\{(1+s_,^2)^{-\frac{3}{2}}-\frac{a}{a_,}(1+s^2)^{-\frac{3}{2}}\right\}$$

$$+(1+2\int U\,dv)\,f(e,\gamma)\,P\gamma^2(1+s_,^2)^{-\frac{3}{2}}\Theta,$$

agreeing with the Formula II. p. 265, except that in Plana's last term, instead of the factor $f(e,\gamma)$ $\left(=\lambda^{\frac{3}{2}}(1+\gamma^2)^{\frac{1}{2}}\right)$, we have the factor $\lambda^{\frac{3}{2}}(1+\gamma^2)^{\frac{1}{2}}$. That is, the last term, as given by Plana, should be divided by $1+\gamma^2$. And this error is introduced from the formula (II.) into the formula (II.)′, p. 267, viz., the incorrect factor $\lambda^{\frac{3}{2}}(1+\gamma^2)^{\frac{1}{2}}$ is there replaced by its value $q$; whereas, the true value being $\lambda^{\frac{3}{2}}(1+\gamma^2)^{\frac{1}{2}}$, the factor in (II.)′ should be $=\frac{q}{1+\gamma^2}$.

The corrected formula (II.)′ is

$$-\frac{d^2\delta u}{dv^2}-\delta u=-Q'\frac{qe}{1+\gamma^2}\cos(cv-\int w\,dv)$$

$$+ q \left\{ (1 + s_1^2)^{-\frac{3}{2}} - \frac{a}{a_1} (1 + s^2)^{-\frac{3}{2}} \right\}$$

$$+ \mu^2 (R_1 + R_2) - \mu^2 \left( \frac{du}{dv}' + \frac{d\delta u}{dv} \right) R,$$

$$- 2\mu^2 \left\{ \frac{d^2 \delta u}{dv^2} + \delta u + q (1 + s_1^2)^{-\frac{3}{2}} \right.$$

$$\left. - \frac{Q' q e}{1 + \gamma^2} \cos (cv - \int w \, dv) \right\} \int R, dv$$

$$- P q \gamma^2 (1 + \gamma^2)^{-1} (1 + s_1^2)^{-\frac{3}{2}} (1 - 2\mu^2 \int R, dv) \left\{ \frac{3}{8} \gamma^2 \right.$$

$$\left. - \left( 1 + \frac{1}{2} \gamma^2 \right) \cos (2gv - 2 \int \ell \, dv) + \frac{1}{8} \gamma^2 \cos (4gv - 4 \int \ell \, dv) \right\}.$$

Observing that P is of the order $m^2$, and that $q$ is approximately equal to unity, the error in $\frac{d^2 \delta u}{dv^2} + \delta u$ is of the order $m^2 \gamma^4$, as noticed above. It may be right to mention that I obtained the correction in the first instance by starting from the fundamental equations, and not as here from the intermediate equation (6), so that there is not in that equation any error afterwards implicitly corrected in the transformation to (II)'.

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## *Jupiter's Satellites: Are they visible to the naked Eye?*

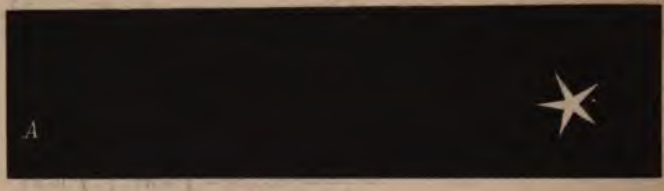
By C. Mason, Esq.

Last evening, on seeing *Jupiter* shining with peculiar brightness in a stretch of sky perfectly clear for some distance around him, I determined upon trying the experiment suggested by one of the Secretaries at the last meeting of the Society,—that of looking for the Satellites of *Jupiter* with the unassisted eye.

On steadying my gaze on the planet, I noted that the rays or streamers surrounding it were five in number, each of them distinct and clearly defined. They were placed nearly as shown in the accompanying rough sketch (see figure A), the widest space or interval between any two points being on the western side of the planet, or to my right hand.

After steadily gazing until I had slowly counted twenty, I suspected flashes of a minute luminous point of blue colour, on the western point of the planet, in the space before mentioned. By the time I had counted thirty the point became fixed and

intensely brilliant. Its position was slightly above an imaginary line drawn parallel to the horizon, through the centre of the




blaze of the planet, and distant rather more than one apparent diameter from *Jupiter's* limb.

Three times successively I withdrew my eyes from the planet, and again, on each occasion, picked up the little star, and always found it in the same position. (See same figure.)

The time of the last observation was 10·14 P.M., G.M.T.; the whole of the observations, from first to last, occupying probably from eight to ten minutes.

I should mention that I applied a kind of test of what I saw, or thought I saw, by inclining my head first to the right and then to the left hand. On these occasions I noticed that the rays or streamers attached to the planet moved round its diameter in the same direction as I moved my head; but the little star was a fixture in its position, and remained visible until, by inclining my head further to the right, the nearest ray or streamer came over and obscured it, the ray having moved round the planet towards the west. The same obscuration took place by the south-western ray, which travelled westward round the planet when I inclined my head towards the east.

On reaching my residence, I first made a sketch of the appearances I have attempted to describe, and then, at 11·15 P.M., turned my refractor, of $4\frac{7}{8}$-inches aperture and 6 ft. 6 in. focal length, upon *Jupiter*, and observed that the whole of the satellites were on the western side, and placed somewhat thus (see figure B).

In the same field, and near the Satellites, were two minute fixed stars, shown also in the sketch.

Until I had referred to the *Nautical Almanac*, a few

minutes before using the telescope, I had not the slightest conception of the relative positions of the Planet and its Satellites for that evening. I therefore am the more strongly impressed with a conviction of having seen the Satellites with the naked eye.

16 *Queen's Road, Regent's Park,*
*April 16th*, 1863.

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*Phenomena of Jupiter's Satellites and Occultations of Stars by the Moon.* Observed by S. Gorton, Esq.

The accompanying observations were taken more with a view of recording unusual phenomena than for the purpose of giving the absolute time of the occurrence, although I believe that to be approximately correct.

As it has been frequently noticed that the stars reappear after being occulted, I have been anxious to observe whether such an occurrence would take place when positively watched for. With the exception of very great "oscillation" on the part of *Jupiter's* Second Satellite, on the 26th ult., I did not perceive anything unusual.

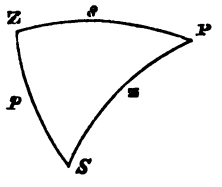
*Jupiter's Satellites: Occultations of Stars by the Moon: observed at Downs Road, Clapton.*

Approximate Longitude, 14° W.

| 1863. | | Local Sid. Time. h m s |
|---|---|---|
| April 19 | Eclipse: Reappearance of Jupiter's 2d Satellite ... | 11 5 9 |
| | (The Satellite was two seconds or more in reappearing; the time therefore is not correct to the exact second.) | |
| 26 | Occultation of Jupiter's 2d Satellite: | |
| | Satellite in contact ... ... | 10 56 0 |
| | ,, bisected ... ... | 11 0 0 |
| | ,, 3 parts covered ... | 11 2 0 |
| | ,, disappeared at ... | 11 3 0 |
| | (The Occultation occupied nearly seven minutes, during which time, owing apparently to the movement of the atmosphere, the Satellite seemed to disappear and appear again several times.) | |
| 26 | The Star *s* Cancri was occulted by the Moon at ... | 12 1 30 |
| 29 | The Star *e* Leonis was occulted at ... ... ... | 12 57 4 |
| | (In both cases the Occultation took place at the Moon's dark limb, and was sharp and instantaneous.) | |

Telescope 4 feet focal length; $3\frac{3}{8}$ inches aperture.

*On the Solution of some Problems in Nautical Astronomy.* By Major-General Hannyngton, late of the Bengal Army.




In the spherical triangle Z P S;

$$\cos P = \frac{\cos p - \cos z \cos s}{\sin z \sin s}$$

$$= \cot z \cot s \,(1 - \sec z \sec s \cos p), \quad (1)$$

also,

$$\cos p = \cos z \cos s + \sin z \sin s \cos P$$

$$= \cos z \cos s \,(1 + \tan z \tan s \cos P), \quad (2)$$

and moreover

$$\frac{\sin z}{\sin Z} = \frac{\sin p}{\sin P} = \frac{\sin s}{\sin S}. \quad (3)$$

The equations marked (1) and (2) are merely transformations. Their symmetry is remarkable, and they appear to be well suited for use in the only two cases that occur in practice, namely,—

(1.) Having three sides, to find the angle opposite to one of them.

(2.) Having two sides and the angle between them, to find the third side.

In either case, the other parts may be found by means of formulæ (3).

If P be the pole, Z the zenith, S the sun or a star, then the angles at those points may be called those of Time, Azimuth, and Position; also, the sides $p$, $z$, $s$, will represent Zenith distance, Polar distance, and Co-latitude.

It is further to be noted, that if a side or an angle exceed 90°, then the affection of the cosine, secant, tangent, and co-tangent of that side or angle is supposed to change and become negative. The cases in which this occurs must be interpreted accordingly.

Formula (1) is applicable to the finding of the Hour-angle, or the Azimuth of a heavenly body, at the instant when its Altitude was observed. By aid of formula (3), a slightly extended process will determine both of these at one operation.

Formula (2) will serve to determine the Altitude of an object when its Hour-angle is known, or the distance between two objects whose Right Ascension and Declination are known. It is, therefore, applicable to the clearing of a Lunar Distance, or to the finding of the Latitude by double altitudes, or to the finding of distances on a great circle.

In the following examples* the *observed* quantities will

* Three only of the nine examples given by the author are printed.—Ed.

generally be used, instead of the sides, to which they are complementary. When a side or angle appears as an intermediate result, any further tabular entries depending upon it will be named accordingly, so that in all cases the quantities in hand will be used unchanged. The data will be taken from Raper's *Navigation*, sixth edition.

### *Formula* (1).

***Ex.* 1.** Alt. 37° 51′; Lat. 51° 10′ N.; Decl. 19° 27′ N.

Find the hour-angle. (Raper, page 202.)

| | | | | | |
|---|---|---|---|---|---|
| Alt. | 37 51 | sin | 9·78788 | | |
| Lat. N. | 51 10 | cosec | 0·10848 | tan | 0·09422 |
| Decl. N. | 19 27 | cosec | 0·47758 | tan | 9·54794 |
| | | log $x$ | 0·37394 | log $(x-1)$ | 0·13532 |
| Hour-angle | $3^h\ 32^m\ 47^s$ | | | cos | 9·77748 |

Here $x = 2{\cdot}3656$, and the sides are each less than 90°, therefore the log of $(x-1)$, *i.e.*, the log of 1·3656 is added to the log tangents. It will be observed that the latitude and declination are of the same name.

### *Formulæ* (1) *and* (2) *combined.*

Clearing a lunar distance.

***Ex.* 7.** App. Alt. ⊙ 47° 31′; True Alt. 47° 30′ 13″
App. Alt. ☽ 36 52; True Alt. 37 37 35
App. Distance 48° 20′ 29″

Find the true distance. (Raper, page 289).

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| App. Dist. | 48° 20′ 29″ | cos | 9·82261 | | | | |
| App. Alt. ⊙ | 47 31 | cos | 0·13225 | tan | 0·03820 | | |
| App. Alt. ☽ | 36 52 | cos | 0·22182 | tan | 9·87501 | | |
| | | log $x$ | 0·17674 | log $(x-1)$ | 9·70091 | | |
| True Alt. ⊙ | 47 30 13 | | | cot | 9·96200 | sin | 9·86766 |
| True Alt. ☽ | 37 37 35 | | | cot | 0·11308 | sin | 9·78569 |
| | | | | log $y$ | 9·68920 | log $(y+1)$ | 0·17286 |
| True Dist. | 47 55 00 | | | | | cos | 9·82621 |

In the first part of this example, $x = 1{\cdot}50224$, and $(x-1) = 0{\cdot}50224$; and in the second part, $y = 0{\cdot}48888$, and

$(y + 1) = 1{\cdot}48888$. The latter part is in effect the converse of the former part, with the true altitudes substituted for the apparent altitudes. As $(x + 1)$ was used in the former part, so $(y - 1)$ is used in the latter part.

### *Formulæ* (1), (2), *and* (3), *combined.*

**Latitude by Double Altitudes.**

*Ex.* 9. Markab R.A. 22h 57m 44s, Decl. 14° 27′ N., True Alt. 58° 55′
Altair R.A. 19 43 53, Decl. 8 30 N., True Alt. 23 30

Find the latitude and the hour-angles. (Raper, page 255.)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Polar Angle | | 3h 13m 51s | cos | 9·82159 | | | | sin 9·87420 |
| Decl. | Markab | 14° 27′ | cot | 0·58891 | sin | 9·39713 | | |
| | Altair | 8 30 | cot | 0·82550 | sin | 9·16970 | cos | 9·99520 |
| | $x = 17{\cdot}219$ | | log $x$ | 1·23600 | log $(x+1)$ | 1·26052 | | |
| | Distance | 47 46½ | | | cos | 9·82735 | cos | 0·13044 |
| | A | 88 27 | | | | | sin | 9·99984 |
| Alt. | Altair | 23 30 | sin | 9·60070 | | | | |
| | Markab | 58 55 | cos | 0·06731 | tan | 0·21980 | | |
| | Distance | 47 46½ | sec | 0·17264 | cot | 9·95780 | | |
| | $y = 0{\cdot}69287$ | | log $y$ | 9·84065 | log $(y-1)$ | 9·48732 | | |
| | B | 62 28 | | | cos | 9·66492 | | |
| | (A − B) | 25 59 | cos | 9·95372 | | | sin | 9·64158 |
| Markab | Decl. | 14 27 | cot | 0·58891 | sin | 9·39713 | | |
| | Alt. | 58 55 | cot | 9·78020 | sin | 9·93269 | cos | 9·71289 |
| | $z = 2{\cdot}1030$ | | log $z$ | 0·32283 | log $(z+1)$ | 0·49178 | | |
| | Latitude | 41 32½ N. | | | sin | 9·82160 | sec | 0·12582 |
| | Hour-angle of Markab | 1h 10m 21s | | | | | sin | 9·48029 |
| Altair Alt. | | 23 30 | sin | 9·60070 | | | | |
| | Lat. N. | 41 33 | cos | 0·17831 | tan | 9·94757 | | |
| | Decl. N. | 8 30 | cos | 0·83030 | tan | 9·17450 | | |
| | $x =$ | | log $x$ | 0·60931 | log $(x-1)$ | 0·48676 | | |
| | Hour-angle of Altair | 4h 24m 7s | | | cos | 9·60883 | | |

The difference of these hour-angles 3h 13m 46s, differs from the polar angle by 5s only. The computed latitude may therefore be relied on. It may be observed that the latitude by account is not an element of our calculation.

*The angle* marked A, is the angle at *Markab*, subtended by

the arc between *Altair* and the Pole; and the angle marked B, is the angle at *Markab*, subtended by the arc between *Altair* and the Zenith. The difference of these (A − B) is the angle of position of *Markab* at the time of the observation. We might in this case, with equal correctness, have determined the latitude by means of the corresponding angles at *Altair*.

The methods herein shown may deserve attention. A little practice would render them familiar, and they require no special tables. Printed forms would also assist the memory and reduce the amount of work.

Trigonometric tables should always have Time arguments. Dr. Inman's, to every second of time, is, for nautical use, extremely convenient. Tables of log $(1 + x)$ and log $(1 - x)$, such as those of Mr. Gray, might advantageously be applied to the foregoing processes.

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*Occultation of κ Cancri, observed at Highbury.*
By T. W. Burr, Esq.

1863, April 26th. The star *κ Cancri* disappeared instantaneously at the dark limb of the Moon at $12^h\ 1^m\ 18^s$, corrected Local Sidereal Time. The reappearance was not observed. Telescope 4 ft. 4 in. focus, $3\frac{1}{8}$ inches aperture. Power 123. Longitude, $24^s$ W.

*Highbury, May 5th*, 1863.

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*Remarkable Phenomenon attending the Lunar Occultation of κ Cancri, on the 26th April*, 1863. By the Rev. W. R. Dawes.

The disappearance of *κ Cancri* at the Moon's dark limb, on the evening of the 26th ult., was observed at West Gorton, near Manchester, by Mr. Ralph Copeland, with a 5-inch refractor by Messrs. T. Cooke and Sons; and the next day the following account of the observation was communicated to me by the observer: —

"The disappearance was very remarkable. About three-fourths of the light disappeared in the usual instantaneous manner; and after an interval of (as near as I could judge) rather more than half a second, the remaining portion disappeared. I did not observe the reappearance."

In a subsequent letter Mr. Copeland says:—"I was so surprised at the totally unexpected phenomenon, that I cannot give the *time*" [*i. e.* the interval between the partial and the total disappearance] "great weight; but I am certain that it was less than one second."

As such a phenomenon points distinctly to the duplicity of the star occulted, I have carefully examined it, under the best circumstances which have since occurred, with my $8\frac{1}{4}$-inch refractor. In hopes that the diminution of the disks by strong twilight might enable me to detect a separation of the components which might not be discernible in a dark sky, on May 1st I set my telescope upon it so early as $6^h\,22^m$ G.M.T., the star being about five minutes east of the meridian. The sun was shining brightly; but the star (of the fifth magnitude) bore sufficiently well a power of 620, and occasionally the disk was tolerably free from tremour and moulding; yet no separation, or even elongation, could be perceived. Subsequently a power of 1000 was applied, with which the disk was at times well seen, but under the best vision it was perfectly round. The observations have since been repeated, though under circumstances scarcely so favourable, but with the same negative result. It would however, I think, be highly desirable that the star should be examined under the best atmospheric conditions, and with refractors of larger size than my own, of which, happily, there are already several in this country.

Two more occultations of *κ Cancri* will occur during the present year, and three in 1864, visible at Greenwich.

As the occultation on April 26th occurred at a convenient time, it may probably have been observed elsewhere; and if so, it would be interesting to know whether any unusual phenomenon was noticed.

*Hopefield Observatory, Haddenham, Thame,*
*May 6, 1863.*

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## *Some Observations of the Lunar Crater Plato.*

By the Rev. W. R. Dawes.

Having been requested by Mr. Birt, who has been so diligently engaged in scrutinising the Lunar Crater termed *Plato*, to examine the floor of that crater with the more powerful means at my disposal, I took advantage of a rather favourable night for that purpose immediately succeeding the receipt of his letter on January 31st; and as some of the points I then made out were, so far as I know, previously unobserved, and subsequent observations have confirmed and extended the discoveries then made, Mr. Birt has requested

me to put the results on record by communicating them to the Society.

Three crater-like spots had previously been noted on the floor of *Plato;* one near the centre, which is the largest, and visible with very moderate optical aid; another toward the south-east; and the third to the north and a little east of the central spot. On the evening above mentioned (Jan. 31st) I noticed that with power 105 this small northern spot was decidedly elongated in an oblique direction, namely, north-east and south-west. On raising the power to 209 I instantly perceived that this apparent elongation arose from the spot being actually *double*, being composed of two very small round crater-like spots, nearly equal in size and brightness, and about one diameter of either apart. All this was seen much plainer with powers from 300 to 620. But whether their circular margins were actually raised above the common level, or whether their interior was depressed below it, I could not determine in the sunlight which then fell upon that part of the moon, her age being about 12·2 days. But on the 26th of April, from $7^h\ 52^m$ to $8^h\ 38^m$, G.M.T., I was so fortunate as to catch a good view of *Plato* as soon as the shadows of the western mountainous ridge were withdrawn from the central spot and the small double one to the north, and while the long spire-like shadow of the fine peak on the western ridge was yet stretching completely across the south-eastern portion of the floor; the northern edge of that shadow actually bisecting the small crater situated in that part. Under these circumstances I was gratified to find that the true character of all these spots was fully brought out, and they were proved to be veritable craters. The eastern wall of the central crater cast a decided shadow on the outside, and the western wall cast a small shadow inwards. Precisely the same appearance was visible in each of the components of the double spot, the length of the exterior shadow of each being, as nearly as I could judge, equal to the diameter of either of them. The appearance of the small crater to the south-east was very similar, but was at first interfered with by the edge of the spire-like shadow which rendered it difficult to be certain of all the details. At $10^h\ 52^m$ G.M.T., however, the apex of this shadow exactly reached the western wall of the crater, and I was then able to make out features of light and shade precisely like the others, but only by transient glimpses, the Moon being then too near the horizon to bear well sufficient power.

There are many other bright spots and streaks on the floor of *Plato;* but the streaks seem to resemble those which extend from some of the principal craters, and show neither elevation above nor depression below the surface over which they pass; and the brighter patches appear to be merely suddenly enlarged portions of these streaks, being irregular in

outline and destitute of elevation. They are all best seen when the Sun's rays fall nearly vertically upon them; while under very oblique illumination they can scarcely be seen at all.

There are two other extremely small spots, one a little to the south-east of the central crater, the other nearly due east of it, which *may*, from their sharp definition and round form, probably be craters; but they require good circumstances and high powers to see them at all; and I could not, on the 26th ult., discern the slightest shadow from either of them.

*Hopefield Observatory, Haddenham, Thame,*
*May 7, 1863.*

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*On a Portion of the Surface of the Mare Imbrium, observed with the Hartwell Equatoreal.* By W. R. Birt, Esq.

The surfaces of most of the so-called lunar seas are characteristically different from all other portions of the lunar surface. A general absence of ruggedness, but few craters, and those only thinly scattered, soft undulating ridges bearing apparently some relation to the borders of the *Maria*, are (with the smaller quantity of light reflected from them) features which at once separate the dusky portions from all others on the lunar hemisphere turned towards the Earth. When the solar light reaches them under a high angle, numerous variations of luminosity are detected, round spots of light that before were invisible manifest themselves, streaks seen to radiate from central craters cross them in various directions, the result being that under a mid-day illumination most of the *Maria* present a well-known mottled appearance, which is scarcely, if at all, observable under either the morning or evening illuminations.

The object of this communication is to place on record a feature by no means so common as any alluded to above. It is a deepening of the tint of the surface, accompanied by a *purity* not to be found in the speckled and mottled surfaces of the *Maria;* and the one I am about to describe appears to be intimately associated with the range of mountains known as the *Alps*, and the bright grounds south and east of *Plato*.

On the evenings of May 2 and 4, 1863, the illumination was sufficiently advanced to bring out, with admirable precision, this deeper tint on the surface of the *Mare Imbrium*. I have thus recorded its appearance at the time of observation: "Bordering the *Alps* from the most extreme end towards the south-west, as far as *Plato*, is a portion of the *Mare Imbrium* of a *pure* dark colour. Its general contour is more *or less parallel* with the *Alps* and the bright ground which

extends in a gentle curve from the *Alps* to *Plato*. Where this border is not interrupted by streaks or spots, the colour is very pure. In the neighbourhood of the south-east extremity of the wedge-shaped valley of the *Alps* this pure colour extends outwards, so that there is a greater space of purer colour absolutely existing at what may be called the estuary of the valley, as if the convulsion which had produced the valley had interfered with the nature of the surface hereabouts. Just preceding this larger extension of the purer colour the greatest interruption of the border occurs in consequence of some rays which proceed from *Aristillus*, the rays extending nearly across the smoother and darker border. The extension of this pure tint of surface in the opening of the valley is curious, opening out as far into the *Mare Imbrium* as the mouth of the valley indents the general border of the *Alps*. Just eastward of the mouth of the valley this pure border is again interrupted by a lighter portion of the surface, on which stand two small craters, close together, marked K by Beer and Mädler. These craters are slightly removed, towards the east, from a line coincident with the direction of the wedge-shaped valley. Proceeding eastward, this border of a deeper and purer colour meets with no further interruption until it terminates south of *Plato*. It appears to take the general form of the bright ground north of it, but widens out a little towards *Pica*.

"The south-east ascent to the summit of the ring of *Plato* completely obliterates this delicate border. Eastward of the south-east ascent it appears again much contracted towards its eastern end, in close proximity with the bright ground extending from *Plato* to the promontory of *Laplace*, and terminating in a fine point north of the middle of a remarkably straight chain of mountains between *Plato* and *Laplace*. It has considerable breadth where it abuts on the brighter ground of the south-east ascent to *Plato*."

This border, which is somewhat indistinctly shown on De la Rue's photographs, is best seen a little before or a little after full moon; good definition is requisite to bring it out well, and the eye should be protected by a slightly-tinted glass.

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## *Elements of the Comets II. and III.*, 1863.

By Mr. Hermann Romberg.

(*Communicated by J. Gurney Barclay, Esq.*)

Both Comets now visible have been frequently observed here, but the reductions are not yet completed. Observations

may probably be continued till the end of the month. By a preliminary calculation on three Leyton observations the following elements have been obtained:—

## *Comet II.* 1863.

(Discovered by Dr. Klinkerfues.)

| | | |
|---|---|---|
| T | 1863, April 5·04696 Greenwich M.T. | |
| $\pi$ | 247° 7′ 42″·3 | Apparent Equinox |
| $\Omega$ | 251 19 32·4 | of April 10. |
| $i$ | 67 13 38·0 | |
| log $q$ | 0·028804 | |

Retrograde.

The errors for the middle observation being only

$$\Delta\alpha = +1''\cdot7 \qquad \Delta\delta = +2''\cdot6 \quad (C.-O.)$$

These elements agree very closely with M. Löwy's, published in the Paris *Bulletin* for April 30. The Comet's appearance is that of a round nebula strongly condensed in the middle, and having a very faint nucleus. It was easily observed during moonlight.

## *Comet III.* 1863.

(Discovered by Prof. Respighi at Bologna.)

For this Comet I have calculated from one Berlin and two Leyton observations the following elements:—

| | | |
|---|---|---|
| T | 1863, April 22·33050 Greenwich M.T. | |
| $\pi$ | 296° 53′ 49″·3 | Apparent Equinox |
| $\Omega$ | 241 14 35·8 | of April 20. |
| $i$ | 84 36 18·9 | |
| log $q$ | 9·788234 | |

Direct.

The appearance of this Comet is much more interesting than that of the second: for the week following April 19 it was a very brilliant little object with low powers on the refractor. It is now visible during the whole night near the northern horizon, and may be observed on the meridian at its transit *sub polo*.

*Mr. Barclay's Observatory, Leyton,*
*May 6.*

## *Observations of the Comets II. and III.*, 1863.
By R. Hodgson, Esq.

### *Comet II.* 1863.

| 1863. | G.M.T. h m s | R.A. h m s | Decl. ° ′ |
|---|---|---|---|
| April 20 | 12 2 13 | 20 27 0 | +15 42 ± |

Apparent size about 4′ of arc, with a bright condensed nucleus.

| | | | |
|---|---|---|---|
| May 1 | 13 1 0 | 19 57 54 | +50 8 ± |

Less bright than on April 20.

| | | | |
|---|---|---|---|
| 4 | 11 40 0 | 19 42 38 | +57 57 ± |

Fast diminishing in brightness.

### *Comet III.* 1863.

| 1863. | G.M.T. h m s | R.A. h m s | Decl. ° ′ |
|---|---|---|---|
| April 26 | 13 50 45 | 0 33 11 | +42 1 ± |

A beautiful object, very brilliant, and a miniature of Donati's Comet; decided stellar nucleus, and tail of at least a degree in length; visible to the naked eye.

| | G.M.T. h m s | h m s | ° ′ |
|---|---|---|---|
| May 7 | 14 0 0 | 2 3 28 | +47 35 ± |

Much less brilliant, and not observable with the naked eye.

*Grove House, May 8*, 1863.

---

## *Observations and Parabolic Elements of Comet III.* 1863.
By M. Karlinski.

| 1863. | Cracow M.T. h m s | Comet's App. R.A. h m s | Log $\left(\frac{P}{\Delta}\right)$. | Comet's App. Decl. ° ′ ″ | Log $\left(\frac{P}{\Delta}\right)$. |
|---|---|---|---|---|---|
| April 18 | 15 5 54·7 | 23 25 53·18 | 9·6264 | +30 44 18·9 | 0·7803 |
| 20 | 14 3 1·5 | 23 41 34·26 | 9·6005 | 34 3 28·6 | 0·8308 |
| ,, | 14 28 11·6 | 23 41 42·60 | 9·6208 | 34 5 13·3 | 0·8104 |
| 21 | 14 26 44·9 | 23 79 57·95 | 9·6249 | 35 37 13·1 | 0·8114 |
| 23 | 14 3 26·4 | 0 6 44·31 | 9·6116 | 38 21 19·1 | 0·8326 |
| May 2 | 14 18 18·1 | 1 24 7·05 | 9·6299 | 45 48 47·2 | 0·8377 |
| 4 | 13 32 59·2 | 1 39 47·07 | 9·5411 | 46 34 31·4 | 0·8772 |
| 5 | 13 41 50·2 | 1 47 38·05 | 9·5553 | +46 52 3·7 | 0·8730 |

Parabolic Elements, computed with regard to Parallax and Aberration, from the observations of 18, 20, and 23 April, are

$$\begin{aligned} T &= 1863, \text{ April } 20{\cdot}89771 \text{ Berlin M.T.} \\ & \quad\ \ ^{\circ}\ \ '\ \ '' \\ \pi &= 305\ 31\ 5{\cdot}6 \\ \Omega &= 279\ 59\ 21{\cdot}7 \quad \text{Mean Equinox } 1863{\cdot}0 \\ i &= 85\ 28\ 73{\cdot}5 \\ \log q &= 9{\cdot}798266 \end{aligned}$$

Motion direct.

*Cracow, May* 6, 1863.

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## RECENT PUBLICATIONS.

*Observations de la Grande Nébuleuse d'Orion faites à Cazan et à Poulkova.* 1re Partie. *Mémoire de M. Liapounov sur les Observations de Cazan.* 2e Partie. *Additions au Mémoire de M. Liapounov, et Observations de Poulkova.* (*Avec* 4 *planches*). 4to. St. Pét. 1862, pp. 1–122; forms part of t. v. of the *Mémoires de l'Académie de St. Pétersbourg*, viie Série.

The chief object of M. Liapounov's Memoir is the construction of a Catalogue of the exact positions of the visible stars of the Nebula, to serve as a point of departure for ulterior researches on the nature of this magnificent star — researches for which a solid basis was given by the labours of Sir John Herschel at the Cape. In the course of his work the author has collected some detached observations, made under favourable atmospheric circumstances, on the regions of the Nebula most accessible by their brilliancy to the power of his telescope; and the results of these observations are given at the end of the Memoir. He remarks, however, that, under the less favourable conditions of his station, such researches presented great difficulties, and that, for this reason, he considers the last-mentioned results as only provisionally established.

The observations were continued regularly in the years 1847–1851, with a single break in the year 1850. The space surveyed, in the neighbourhood of *θ' Orionis*, was about 0·12 of a square degree; whereas the telescope of Sir J. Herschel gave to the Nebula an extent almost double, 0·22 of a square degree.

The stars made out in the space indicated were at first 56 in number; this number was increased to 78 by the *successive discovery* of some more feeble stars. Five more stars,

situate a little beyond the limits mentioned, were afterwards added, making together 83 stars the relative positions of which were to be determined by micrometric measures; but some other stars were observed, making in all 125 out of the 150 stars of Sir J. Herschel; and besides two stars, one of the 9th magnitude, probably excluded by Herschel on account of its too northerly position, the other a star of the 12th magnitude, which is wanting also in the catalogue of Prof. Bond. The Catalogue of the definitive positions in regard to *θ Orionis* of the other 82 stars, is given (pp. 61–63); and the results are compared with those of Herschel and Bond, and of M. Lamont. The concluding part is occupied with physical observations of the Nebula, a drawing of which is given in Plate III.; but it is remarked that the artist has found much difficulty in suitably expressing the relative intensities of the different regions.

The second part, by M. Otto Struve, is in a great measure supplementary to the other. It contains a comparison of M. Liapounov's results with those of Mr. Lassell, obtained by him at Malta in the years 1852 and 1853 (*Mem. R. Ast. Soc.*, t. xxiii.), and a supplementary comparison with the results of Herschel, Bond, and Lamont, and with some other ancient and modern observations. It contains, also, M. Struve's own observations at Poulkova in the years 1856–1862, and, in conclusion, a single Catalogue of the positions in respect to *θ Orionis* of all the stars the existence whereof has been verified with the Refractor at Pulkova. The Catalogue contains, in the order of their Right Ascensions, all the 150 stars of Herschel and 5 supplementary stars. For all the 82 stars measured by Liapounov, the positions are borrowed from his Catalogue; 59 others are introduced, according to the measures and estimations of Herschel, 3 from Lassell's Catalogue, and 1 from that of Bond; for 10 stars the positions are given, such as they were determined at Pulkova. The Plate IV. gives a graphical representation of the relative positions of the stars in the Catalogue, sufficiently accurate to serve for comparison with the heavens, or for the construction, by its aid, of exact drawings of the Nebula.

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# MONTHLY NOTICES

OF THE

# ROYAL ASTRONOMICAL SOCIETY.

VOL. XXIII. *June* 12, 1863. No. 8.


C. B. VIGNOLES, Esq., Vice-President, in the Chair.

The Ven. Archdeacon Garbett, Chichester,
was balloted for and duly elected a Fellow of the Society.

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*On the Indications by Phenomena of Atmospheres to the Sun, Moon, and Planets.* By Professor Challis.

As the Earth has an atmosphere, it is not unlikely that the other bodies of the solar system are similarly furnished, and the knowledge we have of our own atmosphere may reasonably be employed in inquiring whether the existence of other atmospheres of the same kind is indicated by phenomena. I propose, therefore, in this communication to discuss generally the possible effects, observable from a distant position, of an atmosphere constituted like the Earth's, with the view of ascertaining whether such effects have been actually observed.

The most notable effect of the Earth's atmosphere is the refraction of the rays of light which pass through it. In consequence of this refraction, the apparent magnitude of the Earth, as seen by a distant spectator, would be in some degree greater than the apparent magnitude of the globe deprived of its atmosphere, because the rays which pass from the periphery of the globe to the position of the spectator must have a curved course concave to the straight line joining that position and

the Earth's centre. It happens that we are able to calculate exactly the amount of the augmentation in the case of the Earth, independently of any law of variation of the density of the atmospheric strata. I am indebted to Professor Adams for pointing out to me that this inference may be very simply drawn from the construction given by Mr. Sang, in a "Note on the Method of Computing the Moon's Parallax," contained in vol. xv. p. 169, of the *Monthly Notices*. The ratio of E K to E L, which is the ratio of the refractive index for the lowest stratum of the atmosphere to that for the highest, becomes, for the case of a ray which just grazes the Earth's surface, the ratio of E K to E A. Supposing the spectator to be placed at the Moon, this ratio is that of the Moon's horizontal parallax augmented by refraction, to the horizontal parallax unaugmented. As the refractive index for the highest stratum may be taken to be unity, if $\mu$ be the refractive index for the lowest stratum, we thus find that the augmentation is equal to $(\mu - 1) \times$ the Moon's horizontal parallax. This quantity is almost exactly $1''$. A mountain five miles high, situated at the Earth's apparent border, would subtend at the Moon an angle of $4\frac{1}{3}''$, and its top would be somewhat less elevated by the refraction than the base, on account of being higher up in the atmosphere. Thus it appears that the atmospheric refraction would only produce the effect of a slight apparent depression of the mountain. These results show that any atmosphere the Moon can be supposed to have would neither augment her apparent diameter to a perceptible amount, nor alter the forms of the inequalities on the periphery.

There is, however, another effect of atmospheric refraction which might determine whether or not a lunar atmosphere exists. We know that, to a spectator on the Earth, the Sun or a star remains visible above the horizon, by the effect of refraction, when its actual direction falls below the horizon. The same thing would happen to a spectator at the Moon. By reason of the bending of the rays in their passage through the Earth's atmosphere, a star about to be occulted would be visible when its actual direction from the place of the spectator falls within the Earth's apparent periphery. In consequence of the rays by which it is seen being successively more and more bent by the refraction, the star will appear to retire before the Earth's limb, and will disappear suddenly when the rays just graze the Earth's surface. Analogous effects would be produced at a reappearance: the star will be first seen to emerge from the limb when its proper direction falls within the Earth's contour, and will then separate from the limb at an increasing rate till it escapes from the influence of the terrestrial refraction. It is evident that if the Earth's apparent diameter were calculated from the observed times of such disappearances and reappearances, without taking any account of the effect of refraction, *the result* would be much less than the true value.

These considerations show that if the Moon has an atmosphere constituted like the Earth's, her apparent diameter, as inferred from the calculation of occultations of stars and eclipses of the Sun, would be less than the diameter obtained by instrumental measurement, provided the atmosphere produced a sensible amount of refraction. A large number of occultations of stars and planets observed at the Cambridge Observatory, the results of which are exhibited in final equations involving corrections of the quantities assumed in the calculations, might be used for determining this point. It would, however, be necessary in each instance to correct the place of the Moon and that of the star or planet; and, after all, the determination of apparent diameter would be uncertain on account of the liability to error being much greater in observing occultations at bright limbs than in observing those at dark limbs. As far as I have gathered from the mean of a large number of equations, on the supposition that the only error to be corrected is that of the Moon's assumed semi-diameter, the result does not appear to confirm the hypothesis of an atmosphere. On the other hand, the Cambridge observations of the Solar Eclipse of March 15, 1858, reduced so as to correct the tabular differences of the R.A. and N.P.D. of the Sun and Moon, give a correction of the Moon's semi-diameter in the *Nautical Almanac* equal to $-2''{\cdot}96$; and Mr. Airy obtained from a discussion of the Cambridge observations of the Solar Eclipse of July 16, 1833, a like correction equal to $-4''{\cdot}21$. (See *Memoirs of the Royal Astronomical Society*, vol. viii. p. 133, and vol. xxvii. p. 60.)

In an eclipse of the Sun by the Earth, as seen from the Moon, the terrestrial refraction would cause solar rays to reach the Moon, which come from parts of the Sun's disk that are really behind the Earth. There will, consequently, be a condensation of light, so far as this cause operates, bordering the Earth's limb, but extending a very little distance from it, since the whole height of the terrestrial atmosphere, assuming it to be 60 miles, subtends only an angle of $52''$ at the Moon. This light will be much diminished in intensity by having to pass through the dense parts of the Earth's atmosphere, as is evident from the fact that the Sun's face, when near setting, loses so much brightness that it can be looked at with impunity with the naked eye. Also, the rays from this fringe, being divergent, will on that account fall with less intensity on the Moon. But the fringe will remain, and a narrow strip of the Sun's face be apparent long after the disk is geometrically behind the Earth; and the light will generally acquire a ruddy colour by passing, for the most part, through the vapours near the Earth's surface. The red appearance of the Moon's disk during a total lunar eclipse is, as is well known, accounted for in this manner. If we now inquire whether any analogous phenomena are presented in an eclipse of the

Sun by the Moon, we may at once pronounce, considering that if there be a lunar atmosphere, it must be of extreme rarity, that no effect would be at all likely to be discernible, except a slight condensation of solar light bordering the part of the Moon's periphery which crosses the Sun's disk. It is stated by Professor Stephen Alexander, in an account of observations of the total Solar Eclipse of July 18, 1860, published by the Superintendent of the United States Coast Survey, that himself and two other observers saw "a bright band bordering the edge of the Moon which was projected on the Sun's disk." (Appendix, No. 21, to Report for 1860.) It might be doubted from this description whether the band was on the Sun's disk or the Moon's. But, as one of the observers says that he saw "the Sun brighter along the border of the Moon," I conclude that the band was exterior to the Moon's edge. Professor Alexander further states that he first noticed the phenomenon in 1831, and had since, on various occasions, called the attention of others to it; also that "the bright band is unquestionably pictured in the copies of daguerreotypes of the eclipsed Sun." I have referred to these statements in the hope that in future eclipses of the Sun, partial or total, observers may have their attention directed to this appearance, which, as bearing on the question of a lunar atmosphere, is of no little interest.

In the case of an occultation of a star by the Earth, as seen from the Moon, if the strata of the atmosphere were transparent and undisturbed, and everywhere of the same density at the same height above the Earth's surface, the rays by which the star is last or first seen would coincide with rays from the apparent periphery of the Earth, and the star at disappearance or reappearance would, consequently, appear to be exactly on the periphery. But disturbances and variations such as we perceive actually to take place in our atmosphere would destroy this coincidence, and cause the disappearances and reappearances to occur at points separated, on one side or the other, from the Earth's limb. Circumstances of this very kind have been noticed in occultations of stars by the Moon, and would seem to admit of explanation by the hypothesis of a lunar atmosphere. But, although such phenomena, and that above mentioned of the bright band bordering the Moon in a solar eclipse, are reconcileable with the supposition of an atmosphere, they would hardly suffice to prove its existence. An ascertained excess of the Moon's diameter, as measured, above the diameter determined by occultations of stars and solar eclipses, would be a crucial fact, inasmuch as it does not appear that this fact could be accounted for on any other supposition than that of a lunar atmosphere.

I proceed now to consider another effect of atmospheric refraction; in noticing which, as far as I am aware, I have not been anticipated by any previous investigator. Hitherto it *has been* supposed that a ray from a star or other object may

pass *through* the atmosphere in a course which grazes, or is a tangent to, the interior globe. It is evident that in such a case the curvature of the path of the ray is *less* than the curvature of the surface of the globe. But it is conceivable that there may be such a relation between the gradation of density of the atmospheric strata, and the curvature of the globe, that this condition cannot be fulfilled. For instance, it is reasonable to suppose that this is the case in the Sun's atmosphere, when the vast magnitude of the globe is considered, and the usual equation $-k\,d\varrho = G\varrho\,dz$ is taken into account, which shows that the decrement $-d\varrho$ of density corresponding to a given increment $dz$ of height varies conjointly as $\varrho$ the density and G the Sun's gravity. It will, therefore, be worth while to inquire what optical effects will result under these circumstances.

A ray of light proceeding from a point on the surface of the globe, in a direction making an angle with the surface less than a certain limiting angle ($\alpha$), will not pass out of the atmosphere, but will either reach a maximum distance and then return by a like path to the surface again, or will be reflected internally from the upper atmospheric surface, if the atmosphere be of finite density at its superior limit. Conversely, a ray entering the atmosphere from an external body could not impinge on the surface of the globe in a direction making with it an angle less than $\alpha$. It seems necessary to suppose that an atmosphere has an upper boundary like that of an ocean, because, the density continually decreasing with the height, a point must at length be reached at which the upward repulsive force of an atmospheric stratum is just equal to the force of gravity, in which case there can be no downward repulsive force, and therefore no further extension of the atmosphere. Now the limiting angle $\alpha$ is the angle made with the surface of the globe by the course of a ray, which, after traversing the atmosphere and being refracted at the boundary, issues out in the direction of a tangent to the refracting surface. No ray which comes to the eye of a distant spectator can be inclined to the surface of the globe at a less angle than this.

From these considerations it follows (1) that rays proceeding from points of the Sun lying *beyond* the surface which contains all these limiting courses cannot reach the eye of a distant spectator; (2) that rays proceeding from points *within* that surface appear to come from points within the Sun's periphery; (3) that rays proceeding from any points *on* that surface eventually are tangential to the boundary of the atmosphere, and appear to come from the Sun's periphery. Consequently, if the boundary of the atmosphere be spherical, the periphery of the Sun will be an exact circle, notwithstanding any actual inequalities of the surface of the globe. Also, if we may suppose that any objects like clouds are suspended in the solar atmosphere, all the points lying on the limiting

courses will be brought by the refraction to the same level, that is, to the level of the upper boundary of the atmosphere. The augmentation of the Sun's apparent diameter as seen from a distant point will be just equal to the apparent height of the atmosphere.

The foregoing theory fully explains why the contour of the Sun is generally observed to be entirely free from inequalities. This fact is the more remarkable because the unevenness of the Sun's surface, as indicated by the mottled appearance spread over its whole extent, with the occasional occurrence of deep depressions (the spots), surrounded generally by lofty ridges (the faculæ), gives reason to expect that inequalities would be perceptible on the periphery. I am aware that Mr. Dawes has recorded the observation on Oct. 22, 1859, of a phenomenon, which he describes as "a bright streak, which formed the very edge, projecting irregularly beyond the circular contour of the edge." (*Monthly Notices*, vol. xx. p. 56.) This observation, which, as being made by so experienced an observer, must be accepted as trustworthy, by proving the possibility of seeing inequalities, provokes the enquiry, Why are they not more generally seen? The above theory accounts for their not being visible under ordinary circumstances, and at the same time it is possible that the solar atmosphere may be liable, under abnormal conditions, to disturbances and changes of level sufficient to account for the phenomenon Mr. Dawes witnessed. Besides this instance of inequality of contour I am acquainted with only that which was observed on Aug. 4, 1862, by Mr. Howlett, who states that "he plainly perceived a small notch in the Sun's margin, which struck him as not being caused so much by any deficiency in the circular limb of the Sun itself, but rather by reason of abnormally heaped up masses of the contiguous photosphere." (*Monthly Notices*, vol. xxiii. p. 113.) This phenomenon would thus seem to be similar to that seen by Mr. Dawes, and might be due to the same kind of disturbance. In both instances the details of the appearances presented by the spots and faculæ are of an unusual character.

With reference to the second instance, I beg to state that on July 26, at $2^h$ P.M., I saw with the Northumberland Telescope of the Cambridge Observatory the remarkable spot which is the subject of Mr. Howlett's communication. Mr. Todd, the Junior Assistant, who called my attention to it in the temporary absence of Professor Adams, took a sketch of it. The sketch is, consequently, intermediate to those of July 25 and 27, figured in pp. 110 and 111 of the *Monthly Notices*, above cited. The peculiarity of small nuclei situated on the edges of large patches of penumbra is exhibited, with great changes in the details, in this as in the other sketches. What chiefly struck me was a bridge stretching across the principal nucleus, remarkably bright, and not bounded by a penumbra.

I judged it to be brighter than the general surface of the Sun. Mr. Howlett, describing its appearance on July 25, calls it "a remarkable mass of brilliant photospheric matter," at which time it had not decidedly assumed the form of a bridge. This phenomenon and the peculiarity above mentioned, with the dislocated appearance of the adjacent patches of penumbra, seem to be indicative of an unusual amount of disturbance.

With respect to indications of the existence of atmospheres to the planets, little can be said relative to the effects of atmospheric refraction. From what was proved at the beginning of this communication, the apparent semidiameters will most probably not be sensibly increased if the refraction be of the first kind; and if of the second kind, the increase would be the angle which the whole height of the atmosphere subtends at the Earth, and would vary with distance according to the same law as the apparent semidiameter. Supposing the refraction of *Jupiter's* atmosphere to be of the first kind, a satellite would probably be eclipsed as soon as the atmosphere interferes with its visual direction, because the deviation and divergence which the rays undergo by incidence on the atmosphere, might at once render them invisible at the great distance of the Earth. If otherwise, the satellite would diminish in brightness before disappearing, and such diminution might be taken as evidence of the existence of an atmosphere. If the refraction were of the second kind, the satellite would disappear without diminution of brightness, just as if it had been eclipsed by an opaque body. The most direct physical evidence of a planet's atmosphere would be the constant recurrence of variable appearances on the disk known not to be due to rotation, it being hardly conceivable that such appearances can have any other origin than the suspension and motion of cloud-like substances in an atmosphere. Such phenomena are observable on the disks of *Jupiter* and *Saturn*, and, as would seem from recent observations, on that of *Mars*.

It remains to notice one other phenomenon indicative of an atmosphere: a distant spherical body, whether self-luminous or shining by reflected light, would, according to the law that the intensity of the radiation varies as the sine of the angle which the direction of emanation makes with the surface, appear equally bright at all points of the disk. But an atmosphere to the body, of considerable magnitude and constituted like the Earth's, would intercept more of the rays coming from the parts near the periphery than of those coming from near the centre of the disk, because the former would pass through a greater thickness of atmosphere. There would, in consequence, be a gradual diminution of brightness from the centre to the circumference. This phenomenon is, in fact, plainly discernible in a photographic picture of the Sun, or in an image received on a screen, and is so simply explained by the above considerations, that it almost justifies of itself the inference that

the Sun has an atmosphere. The effect would be produced whether the atmospheric refraction be of the first of the two kinds before mentioned, or the second, but would be less conspicuous in the latter case than in the other. With respect to *Jupiter*, also, I have frequently remarked, that the features of the disk appeared more distinct near the centre than towards the periphery; and on the occasion of the occultation of this planet on January 2, 1857, I made the note that when it emerged from the Moon's bright limb, it appeared "brighter at the central parts than towards the border, and had in consequence something of a pellucid appearance." (See *Monthly Notices*, vol. xvii. p. 138). These phenomena are readily explained by the supposition of an atmosphere.

*Cambridge, April* 13, 1863.

---

*On an Eclipse of the Sun recorded in the Chinese Annals as having occurred at a very early Period of their History.* By Mr. Williams, Assistant-Secretary.

A few weeks since Mr. Hind requested me to look into the annals of China, with a view of ascertaining the particulars of a very early Solar Eclipse, said to be recorded in their most ancient historical work, the *Shoo King*, a copy of which is in my possession. I accordingly undertook the task, and the information thus obtained appearing to be of considerable interest, I am induced to lay it before the Society, it being the earliest record known of a Solar Eclipse. I therefore will very briefly give the result of this investigation, explaining, at the same time, the process by which it has been obtained. It is to be remembered that it is the Chinese account only I now lay before you, leaving its corroboration or disproval to those more competent than myself to enter into that part of the subject.

In the 書經 *Shoo King*—the most ancient historical work of the Chinese—in the second section of that work, under the 夏 Hea Dynasty, it is related that, in the reign of 仲康, Chung Kang, the fourth Emperor of that Dynasty, an Eclipse of the Sun took place. The passage recording this Eclipse occurs incidentally in an account of the delinquency of 羲 He and 和 Ho, two important officers, who appear to have had the superintendence of the Imperial Astronomical Board, as it may be called, and who, giving themselves up to wine, neglected their duties, and consequently, failing in the prediction of the Eclipse in question, rendered themselves

liable to punishment for that offence. The prediction of an eclipse was a matter of very great importance in China, as certain religious ceremonies were required to be performed, both by the Emperor and the people on these occasions, of which it was necessary that due notice should be given, in order that the requisite preparations should be made.

The passage recording the Eclipse is as follows, beginning to the right and reading downwards :—

| | | |
|---|---|---|
| 集 Tseih | 朔 So | 季 Ke |
| 于 Yu | 辰 Shin | 秋 Tsew |
| 房 Fang | 弗 Foo | 月 Yue |

which may be rendered, "In the last month of the autumn, the first day of the moon, the heavenly bodies were not in agreement in Fang."

I have not hitherto been able to find, in the *Shoo King*, any more definite date assigned to this Eclipse; but in other historical works in my possession the following passage occurs in each, which supplies this deficiency :—

| | | |
|---|---|---|
| 元 Yuen | 夏 Hea | 壬 Jin |
| 歲 Suy. | 仲 Chung | 戌 Seuh |
| | 康 Kang | |

This passage requires some explanation to render the observations that follow intelligible. The first two characters (Jin Seuh) are the cyclical characters of the year in question; the next (Hea) is the name of the dynasty; the next two (Chung Kang) are the name of the Emperor; and the last two (Yuen Suy) express "the first year." This sentence, then, is to be rendered, "In the year Jin Seuh of the Cycle, the first year of Chung Kang of the Hea Dynasty." The account that immediately follows this passage does not directly relate to the subject of the Eclipse, and is followed by the before-mentioned words of the *Shoo King*, commencing with "Tsew," and with the character for nine before the word "Yue" (month), consequently reading, "In the autumn, the ninth month, the first day of the moon," &c.

The notes in each of these works explain this passage as relating to an Eclipse of the Sun. In two of them we have a

further explanation of some of the expressions employed. Thus "Shin," the fifth character, is said to signify the "Sun and Moon;" and it is intimated that these luminaries are described as not being in "harmonious agreement in the division Fang."

It must, however, be mentioned, that in the great collection of Chinese historians, in three hundred volumes, entitled *She ke*, "*Historical Annals*," the early part of which was compiled in the century before the Christian era, although the neglect of He and Ho and their subsequent punishment are mentioned, no account of the occurrence of an Eclipse is given.

We have then, in the passage just quoted, a positive date assigned to this Eclipse, viz. "Jin Seuh," a certain year of a cycle, and the ninth month of that year. It remains, then, to show how this date is to be expressed in our notation. The mode of effecting this is, when explained, exceedingly simple, and the following is the course to be pursued:—The Chinese regulate their chronology by periods or cycles of 60 years. The years of these cycles are indicated, not by numerals, but by certain characters called by them Kea Tsze. These they divide into two series, the one of ten, the other of twelve characters, and the name Kea Tsze is derived from the names of the first characters in these series. They are employed in the following manner:—Combining the first characters in each series, we obtain the appellation of the first year of the Cycle, Kea Tsze. The second characters are combined for the second year, and so on to the eleventh, when the first character of the shorter series combines with the eleventh of the longer; and at the thirteenth the third of the shorter series combines with the first of the longer for the appellation of that year. Thus it goes on until, in the sixtieth year, the two last characters combine to form 60, and are followed in the sixty-first year by Kea Tsze, as before, when a new cycle commences.

We are now prepared to investigate the date of this Eclipse, as given in the Chinese annals. Upon examination, the characters at the commencement of the passage quoted (Jin Seuh) are found to be those answering to the fifty-ninth year of the cycle; and this particular cycle is considered by the Chinese to be the eighth of their series. Now it is reckoned that the seventy-fifth cycle commenced in the year 1804 of our era: consequently, seventy-four cycles were completed in 1803. Hence $74 \times 60 = 4440$ will give the number of years elapsed since the commencement of this mode of reckoning to 1803. Subtracting from that number the years of the Christian era, 1803, we obtain 2637 B.C. for the first year of the first cycle. Now we gather from the text, that the first year of Chung Kang was the fifty-ninth year of the eighth cycle, and, consequently, that seven cycles and fifty-nine years would be completed in that year. Consequently, that year was $7 \times 60 + 59 = 479$ years from the commencement of *the cyclical* mode of reckoning. Subtracting this from 2637,

we obtain 2158 B.C. as the date of the accession of Chung Kang; and as the eclipse occurred in the autumn of the same year, it must also be the date of that phenomenon.

We have now to consider the part of the heavens mentioned as the place where the eclipse took place; and here I may be allowed a few words in explanation of the mode in which the Chinese astronomers arrange the stars.

The visible heavens are divided by them into thirty-one parts. Three of these, called "yuen," are of considerable size. The first, called "Tsze wei yuen," comprises the Circumpolar stars, and may be considered as including those that never set in China. The second, named "Tai wei yuen," is bounded to the south by stars in *Virgo* and *Leo*, and includes to the north *Coma Berenices*, *Canes Venatici*, and some stars in *Ursa Major*. The third, "Teen she yuen," is bounded by stars in *Serpens* and *Hercules:* thus including the greater portion of *Ophiuchus*, the constellation *Hercules*, and other stars to the north.

The remaining twenty-eight divisions, called "Suh," of which *Fang* is one, may be considered as representing the lunar houses. They, however, are very irregular in extent, both from east to west and from north to south. Thus, while the smallest is less than one degree from east to west, the largest extends thirty-one degrees, and of the rest no two are alike in dimensions. In like manner, while one extends north and south from *Perseus* to *Canopus*, another consists merely of a few small stars in the head of *Orion*. Each of these twenty-eight divisions is determined by a certain group of stars having the name of the division, but frequently forming a very small portion of it, the name being common to the whole division, which may include various other asterisms wholly unconnected with the group thus named.

Thus, in the most extensive division Tsing, the group of stars so called consists of $\gamma$, $\varepsilon$, $\lambda$, $\mu$, and other stars in *Gemini*, but the whole division extends 31° from east to west, and from *Perseus* in the north to *Canopus* in the south. It is necessary, in speculating on any phenomenon recorded in the Chinese books, to keep these circumstances in view, as an appearance described in these records as having occurred in Tsing, may be referred to any part of that division, and thus, without more definite information, its probable place cannot be identified with any degree of certainty.

The division Fang, in which this Eclipse is said to have occurred, is a very small one, being only about five degrees from east to west, and of but little extent from north to south. Its determining group consists of the stars $\beta$, $\delta$, $\pi$, and $\rho$ in *Scorpio*. It includes also a few small stars in *Libra* and *Ophiuchus* to the north, and in *Lupus* to the south. This, then, is the part of the heavens in which the Eclipse occurred; and, as it is a Solar Eclipse that is recorded, I presume there would be but little

difficulty in ascertaining the exact place of the Sun at the time mentioned.

The result then of this investigation, as far as I have carried it, is, that a Solar Eclipse is recorded in the most ancient Chinese historical work extant, as having occurred in the reign of Chung Kang, of the Hea dynasty, which Eclipse is more circumstantially mentioned by subsequent historians as having taken place in the first year of that Emperor, being the fifty-ninth year of the eighth cycle. That according to their mode of reckoning, the date of this Eclipse, expressed in our numbers, is 2158 B.C. and that it occurred in the ninth month of that year, in their division Fang, that asterism being part of our constellation *Scorpio*.

I have thus given the account of this Eclipse, simply as it occurs in Chinese historical works of reputation. There are, however, discrepancies in the year of the founding of the Hea dynasty, both in Chinese and European authorities, which may require attention. Leaving out one Chinese author, whose difference is upwards of 200 years, I find the first year of Yu, the founder of that dynasty, was according to one authority 2206, and according to the historians I have followed in this investigation 2204 B.C. According to what may be called European authorities, we have in Du Halde 2208, and in Gaubil 2205, as the date of that event. We have here then a difference of about four years, within which limits, I presume, should a Solar Eclipse be found to have occurred, satisfying the conditions as to time and place, it may reasonably be considered as that recorded in the curious and ancient book from which the preceding account has been taken.

I have also thought it necessary to give important passages in the original characters, knowing from experience the extreme difficulty of ascertaining with any degree of certainty the actual words intended to be employed, when their equivalent sounds are expressed in European letters only.* Whether a Solar Eclipse, visible in China, actually occurred at or near the time mentioned must be left for others to determine; and I can only say in conclusion, that should such be found to have been the case, it will afford a strong evidence of the general veracity of the early annals of that very ancient and interesting people.

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### *On the Value of the Solar Parallax deduced from the Lunar Tables.* By P. A. Hansen.

In the *Monthly Notices*, vol. xxiii. No. 7, Mr. E. J. Stone discusses different values of the co-efficient of the Parallactic

* For the loan of the Chinese type employed in this paper, the Society is *indebted to* Mr. Watts, Printer, of Crown Court, Temple Bar.

Equation of the Moon, and closes his note with the following words:—"It would be a point of interest to determine whether Professor Hansen's theory would bear any considerable increase in the mean Solar Parallax." I fulfil this desire with all the more pleasure, since the determination of the Solar Parallax from my Lunar Tables may be obtained by means of data which have been already published.

On page 177 of the *Darlegung der theoretischen Berechnung der in den Mondtafeln angewandten Störungen*, it will be found, that in my calculation of perturbations for the ratio of the major semi-axis of the orbits of the Earth and Moon, I have adopted the following value:—

$$\log \frac{a}{a'} = 74034757$$

which gives, for the co-efficient of the Parallactic Equation 121″·368 (Lunar Tables, p. 8). By comparison with observations, however, it results that all inequalities, theoretically calculated with the above value of $\frac{a}{a'}$, must be multiplied by the factor 1·03573 in order to conform to the observations. When, therefore, the above-mentioned co-efficient is multiplied by this factor, it gives 125″·70, which coincides very nearly with the value which Mr. Airy has obtained by the Altazimuth.

Further, in the Lunar Tables (p. 4), the constant of the Parallax of the Moon is given as = 56′ 59″·57. This being multiplied by the above value $\frac{a}{a'}$, we have 8″·66 for the Solar parallax, which has been adopted as the basis of the theoretical calculations. This, again, being multiplied by the above factor 1·03573, the Solar Parallax, determined by the elaboration of the Lunar Tables, becomes 8″·97. This value coincides very nearly with that which has been determined by the last opposition of *Mars*.

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## *On the Companions of Sirius.* By M. Goldschmidt.

(*Extract from a Letter to Admiral Manners, Secretary of the Royal Astronomical Society.*)

I have seen with satisfaction the insertion of my letter from M. l'Abbé Moigno's journal, *Les Mondes*, in your *Monthly Notices*, No. 5, vol. xxiii. I hope that *Sirius* will be observed next autumn by astronomers provided with large telescopes, to verify the minute stars I saw in its following vicinity. As long as *Sirius* was high enough above the horizon, I could see them; but afterwards I perceived only mere glimpses of light,

without being able to distinguish the position of the stars. On the top of the wood-cut in the *Monthly Notices*, No. 5, is written "*Position des Satellites:*" these words are not mine, for I cannot believe that they are all satellites. In the possibility that some of these luminous points could perhaps be the result of optical illusion or sickness of my eyes, I tried the same kind of observation (by passages) with some brilliant stars, like *Altair* and *Antares*, but I could see nothing like that I perceived on *Sirius;* and so, having done all that is in my power, with an object-glass of only 4 inches (English measure) or 46 lines, to snatch such minute light points, I leave it to more skilful astronomers to do the rest; for a powerful telescope with clock-work and the star hidden behind a large plate would show this wondrous system. The distance of the star D I tried to measure on the moment of its discovery, and it might be distant east from *Sirius* $3^{s}\cdot60$ or $3^{s}\cdot80$ in Right Ascension. I found also another fainter and distant star (perhaps $10''$) in the vicinity, and on the east of the star D, which I announced in my first letter to Mr. Peters, on the 8th of March. On writing this, I received the news of Rev. Mr. Dawes' observation of the star D. It is, indeed, the most conspicuous of all by its *distant position*; but I think that the two nearest ones are more brilliant, and seem to be bodies of great importance relative to *Sirius*.

*Paris, le 5 Juin*, 1863.

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*On the Discordance between the Results for Zenith Distances obtained by direct Observation and those obtained by Observation by Reflexion from the Surface of Quicksilver.* By G. B. Airy, Esq., Astronomer Royal. (Abstract.)

After explaining the manner in which the discordance in question is practically taken account of at the Greenwich Observatory, the author remarks that, in preparing for the formation of the new Seven-Year Greenwich Catalogue of Stars, it appeared to him desirable to examine carefully the results of the reductions (extending over a quarter of a century) which have been conducted on the principle described, with the view of ascertaining whether the Direct Observations ought to be used alone, or whether the Reflexion Observations ought to be used alone, or whether the mean of them ought to be used, as has been done in the Annual Reductions; and that the object of the Memoir is to give the result of this inquiry. It appears that neither the D observations nor the R observations can be adopted, without correction, as sufficiently accurate, but that the D observations corrected by $\frac{1}{4}(R-D)$, or still better by $\frac{3}{5}(R-D)$, give accordant values

of co-latitude, and may be received as perfectly accurate; and it is inferred that the correction $\frac{1}{2}(R-D)$ or $\frac{2}{3}(R-D)$ is a real correction, founded on some physical cause. There is no room for explanation from defects of the instruments. A suggestion is, however, offered as to the nature of the physical cause of $R-D$, viz. from a comparison of the results for three different periods, for which different shutter-openings were used in the observing-room, it appears to be probable that the origin of the discordance expressed by $R-D$ lies in some conformation of the warmer and cooler strata of the atmosphere in the immediate neighbourhood of the Instrument. The concluding paragraphs of the Memoir are as follows:—

"It is to me a matter of great satisfaction to be assured that the enormous number of observations made at Greenwich from 1836 have been reduced on principles which are fundamentally correct, and which scarcely leave appreciable error. But I think that the investigation leads to inferences of a broader and still more important kind. It appears probable that no co-latitude of an Observatory, where direct observations alone are used, is certain to a quarter of a second, and no north polar distance of stars at 70° or 80° from the pole is certain to half a second. I know no method of removing this doubt but the introduction of reflexion observations of stars on both sides of the zenith.

"I ought not to close this paper without acknowledging that my first ideas of connecting the discordance of direct and reflexion observations with the circumstances of the observing room, were derived from a conversation with Mr. Faye, when I had the pleasure of seeing him at Greenwich, on the occasion of determining the difference of longitude between Paris and Greenwich in 1854. At the time of reading his valuable paper in the *Comptes Rendus*, 1850, September 16, there was no critical evidence as to the cause of the discordance; and even in 1854, when the observations as far as 1852 were thoroughly reduced, there was not a sufficient amount of evidence under the new circumstances of the Instrument to enable me to form a decided opinion. It is only with the accumulation of evidence in later years, exhibiting results so consistent among themselves, but so distinctly opposed to those of former years, that the possibility has presented itself of pronouncing with certainty on the general origin of the discordance, and on the way in which, astronomically, it ought to be treated."

*Observations on the Planet Mars.* By J. N. Lockyer, Esq. (Abstract.*)

The author mentions that during the opposition of last year, in spite of the generally very unfavourable state of the weather, he was able to make a series of sketches which embraced a complete rotation of the planet; and that the opposition of last year, occurring on the 5th October in heliocentric longitude 12°, afforded the opportunity, among other things, of fairly comparing the series with the one taken by MM. Beer and Mädler in 1830, when the opposition took place the 19th September, in heliocentric longitude 356°. As regards the permanency of the features, the general result is that the two series of drawings agree in a marvellous manner, the author's very much larger instrument revealing no main feature which was not foreshadowed in the earlier series, although, from the greater light of his own telescope, he was enabled to study the details in a more satisfactory manner. But, although the complete fixity of the main features of the planet seems to be thus ascertained beyond all doubt, there occur daily, nay hourly, changes of detail, and in the tones of the different parts of the planet, both light and dark—changes which, he doubts not, are caused by the transit of clouds over the different features.

The larger part of the Memoir consists of comments on the drawings, and the comparison of them with the earlier series.

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*Results of the Meridional Observations of Small Planets; Occultation of a Star by the Moon; and Phenomena of Jupiter's Satellites; observed at the Royal Observatory, Greenwich, in the months of April and May, 1863.*

(*Communicated by the Astronomer Royal.*)

*Astræa* ⑤.

| Mean Solar Time of Observation. | | R.A. from Observation. | N.P.D. from Observation. |
|---|---|---|---|
| | h m s | h m s | ° ′ ″ |
| 1863, April 1 | 9 9 5·8 | 9 47 59·70 | 73 14 55·78 |
| 2 | 9 5 17·8 | 9 48 7·59 | 73 14 3·28 |
| 7 | 8 46 45·0 | 9 49 14·56 | 73 12 21·02 |
| 18 | 8 8 28·3 | 9 54 13·62 | 73 25 28·52 |

* The Memoir, with the accompanying drawings, or a selection from them, will probably appear in the volume of *Memoirs*. The drawings were exhibited at the Meeting of the Society.—Ed.

## *Metis* (9).

| Mean Solar Time of Observation. | R.A. from Observation. | N.P.D. from Observation. |
|---|---|---|
| h m s | h m s | ° ′ ″ |
| 1863, May 13 13 20 27·4 | 16 45 37·84 | 111 51 40·16 |
| 21 12 41 16·0 | 16 37 52·48 | 111 52 27·18 |
| 22 12 36 18·6 | 16 36 50·80 | 111 52 21·44 |
| 23 12 31 20·8 | 16 35 48·75 | 111 52 14·02 |
| 25 12 21 23·4 | 16 33 42·78 | 111 51 57·23 |

## *Irene* (14).

| Mean Solar Time of Observation. | R.A. from Observation. | N.P.D. from Observation. |
|---|---|---|
| h m s | h m s | ° ′ ″ |
| 1863, April 7 9 21 44·7 | 10 24 19·96 | 64 43 7·77 |
| 13 8 58 11·5 | 10 24 22·20 | 65 12 29·61 |

## *Eunomia* (15).

| Mean Solar Time of Observation. | R.A. from Observation. | N.P.D. from Observation. |
|---|---|---|
| h m s | h m s | ° ′ ″ |
| 1863, April 7 12 25 40·0 | 13 28 45·53 | 117 34 4·92 |
| 20 11 22 43·5 | 13 16 53·86 | 116 35 0·70 |
| 23 11 8 17·2 | 13 14 14·79 | 116 17 42·81 |
| 30 10 34 58·1 | 13 8 26·15 | 115 33 51·84 |
| May 4 10 16 14·2 | 13 5 25·34 | 115 7 10·54 |
| 7 10 2 20·5 | 13 3 19·10 | 114 46 44·39 |

## *Psyche* (16).

| Mean Solar Time of Observation. | R.A. from Observation. | N.P.D. from Observation. |
|---|---|---|
| h m s | h m s | ° ′ ″ |
| 1863, April 7 13 44 35·1 | 14 47 53·57 | 102 7 0·74 |
| 16 13 3 16·5 | 14 41 57·17 | 101 31 40·09 |
| 20 12 44 37·5 | 14 39 1·28 | 101 15 4·27 |
| 23 12 30 33·3 | 14 36 44·41 | 101 2 26·86 |
| 25 12 21 8·9 | 14 35 11·62 | 100 54 2·75 |
| 28 12 7 0·6 | 14 32 50·66 | 100 41 25·34 |
| 30 11 57 34·8 | 14 31 16·43 | 100 33 7·65 |
| May 1 11 52 51·6 | 14 30 28·94 | 100 28 58·33 |
| 2 11 48 8·8 | 14 29 41·99 | 100 24 50·95 |
| 4 11 38 42·9 | 14 28 7·64 | 100 16 41·95 |
| 13 10 56 31·3 | 14 21 18·12 | 99 42 29·34 |
| 21 10 19 36·5 | 14 15 49·66 | 99 16 41·99 |
| 25 10 1 28·0 | 14 13 24·41 | 99 5 56·36 |
| 26 9 56 53·4 | 14 12 50·62 | 99 3 30·92 |

## *Bellona* (28).

| Mean Solar Time of Observation. | | R.A. from Observation. | N.P.D. from Observation. |
|---|---|---|---|
| | h m s | h m s | ° ′ ″ |
| 1863, April 1 | 8 23 18·6 | 9 2 5·03 | 71 1 39·41 |

## *Harmonia* (40).

| Mean Solar Time of Observation. | | R.A. from Observation. | N.P.D. from Observation. |
|---|---|---|---|
| | h m s | h m s | ° ′ ″ |
| 1863, April 16 | 13 7 16·2 | 14 45 57·53 | 99 31 24·01 |
| 20 | 12 47 53·2 | 14 42 17·56 | 99 15 7·71 |
| 23 | 12 33 12·5 | 14 39 24·06 | 99 3 3·94 |
| 25 | 12 23 22·5 | 14 37 25·55 | 98 55 3·58 |
| 28 | 12 8 34·4 | 14 34 24·74 | 98 43 20·96 |
| 30 | 11 58 41·6 | 14 32 23·43 | 98 35 47·96 |
| May 1 | 11 53 45·0 | 14 31 22·56 | 98 32 7·53 |
| 2 | 11 48 48·8 | 14 30 22·12 | 98 28 28·57 |
| 4 | 11 38 56·1 | 14 28 20·83 | 98 21 26·91 |
| 7 | 11 24 10·0 | 14 25 22·00 | 98 11 32·79 |
| 8 | 11 19 15·4 | 14 24 23·15 | 98 8 27·66 |
| 13 | 10 54 52·8 | 14 19 39·37 | 97 54 41·76 |
| 21 | 10 16 43·4 | 14 12 56·12 | 97 39 28·71 |
| 22 | 10 12 2·8 | 14 12 11·31 | 97 38 13·24 |
| 23 | 10 7 23·6 | 14 11 27·86 | 97 37 12·66 |
| 25 | 9 58 9·7 | 14 10 5·63 | 97 35 27·66 |
| 26 | 9 53 35·2 | 14 9 26·94 | 97 34 54·25 |
| 28 | 9 44 30·6 | 14 8 13·95 | 97 34 9·68 |

## *Diana* (78).

| Mean Solar Time of Observation. | | R.A. from Observation. | N.P.D. from Observation. |
|---|---|---|---|
| | h m s | h m s | ° ′ ″ |
| 1863, April 15 | 10 0 8·2 | 11 34 22·23 | 96 10 13·04 |

All the observations of N.P.D. have been corrected for Refraction and Parallax.

## *Occultation of a Star by the Moon.*

| Day of Observation. | Phenomenon. | Moon's Limb. | Mean Solar Time. | Observer. |
|---|---|---|---|---|
| 1863. | | | h m s | |
| Apr. 26 | $\kappa$ Cancri, disapp. | Dark | 9 44 24·0 | C. |
| 26 | $\kappa$ Cancri, reapp. | Bright | 10 53 15·5 | C. |

*Phenomena of Jupiter's Satellites.*

| Day of Observation. 1863. | Satellite. | Phenomenon. | Mean Solar Time. h m s | Observer. |
|---|---|---|---|---|
| April 1 | II | Eclipse, disapp. | 12 18 35·7 | E. |
| 20 | III | Ingress, bisection | 14 14 42·7 | E. |
| 26 | II | Eclipse, reapp. | 11 51 25·5 | C. |
| 28 | I | ,, reapp. | 11 6 45·3 | E. |
| May 1 | III | ,, reapp. | 11 26 4·9 | R. |
| 8 | III | Occ. disapp. last cont. | 10 39 53·4 | N. |
| ,, | III | Occ. reapp. last cont. | 13 1 37·6 | R. |
| ,, | III | Eclipse, disapp. | 13 3 52·3 | R. |
| 21 | I | ,, reapp. | 11 17 34·9 | E. |
| 26 | III | Egress, last cont. | 9 30 59·6 | C. |
| 28 | II | Eclipse, reapp. (*a*) | 11 37 10·5 | J. C. |

(*a*) Probably late, the planet being very faint from cloud.

The initials E., C., J. C., R., and N., are respectively those of Mr. Ellis, Mr. Criswick, Mr. Carpenter, Mr. Roberts, and Mr. Nash.

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Fig. 1.

Plato Sunrise. Rev. W. R. Dawes, 1863, April 26$^{d}$ 1$^{h}$ +. Degree of illumination 0·03.

Fig. 2.

Plato Sunset. W. R. Birt, 1863, May 10$^{d}$ 15$^{h}$ 56$^{m}$. Degree of illumination 0·99.

Fig. 1 is intended to illustrate Mr. Dawes' paper on *Plato*, inserted in the last number of the *Monthly Notices*. The four crater spots on the floor are shown in the engraving. Fig. 2 exhibits the appearance of *Plato* at sunset, or more accurately within three hours of the sun setting in the western edge of *Plato*. Both sketches were taken during the same lunation, April and May, 1863.

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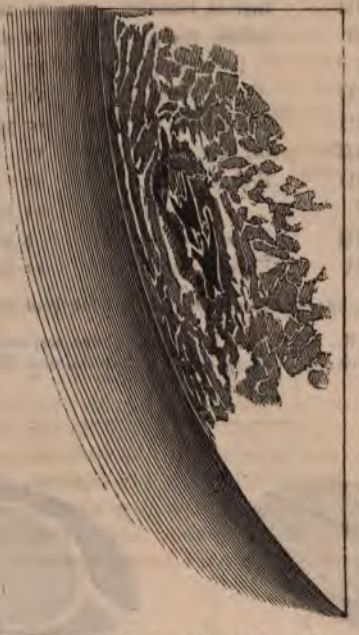
*Observation of a Solar Facula.* By Capt. W. Noble.

While examining the Sun on the 24th of May, at 3$^{h}$, G.M.T., my attention was directed to a spot which was

just coming on to his following limb. Upon scrutinising the neighbourhood of this spot, I was at once attracted by the remarkable appearance presented by a facula situated between the spot referred to and the limb itself; an appearance depicted in the accompanying sketch. It was that



Part of the Sun's Limb, Sunday, May 24th, 1863. $3^h$, G.M.T.

of a most extraordinary elevation above the general level of the Sun's apparent surface, the facula exhibiting quite a dark line on its following edge, and presenting a perfectly stereoscopic effect. My first impression was that this was an optical illusion, and that what I took for the shading on the following side of this enormous ridge of light was really a spot or macula excessively foreshortened. Upon looking at the Sun, however, when this suppositious spot *should* have arrived fairly on to his disk by his rotation, I found the neighbourhood a perfect blank, the spot, following which I had first observed the facula, being quite isolated. The drawing which I send was made, *ad naturam*, with a power of 154. Owing to the employment of a "Hodgson" eye-piece, a double reversal of the image has necessarily taken place. I have marked the facula *a*. The extreme length of the penumbra of the spot to the right of it, was as nearly as possible 0″·8 of arc, which will supply the scale to which the sketch was made.

*Forest Lodge, Maresfield, Sussex,*
*June*, 1863.

## *Eclipse of the Sun, May 17th, 1863.*
By Capt. W. Noble.

The first indentation of the Moon upon the Sun's limb was observed about $9^h\ 24^m\ 37^s$ local sidereal time $= 5^h\ 44^m\ 55^s{\cdot}3$ local mean time. The Moon's limb was relatively smooth. The sky was very cloudy, and it was only at intervals that a distinct glimpse of the solar disk could be obtained. A slight break enabled the greatest phase to be observed. The Sun set densely obscured in a bank of clouds. Powers 42 and 74, approximate latitude and longitude $51°\ 0'\ 58''$ N., and $17^s{\cdot}5$ E.

*Forest Lodge, Maresfield,*
*11th June*, 1863.

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## *Total Eclipse of the Moon, June 1st, 1863.*
By Capt. W. Noble.

The singularly undefined character of the edge of the Earth's shadow, as viewed in the telescope, rendered anything like observations of Time hopeless. At the time of the middle of the eclipse, the lunar detail was well seen with a power of 42, save just in the centre of the shadow, where everything was obscured. I cannot remember ever to have seen such a nebulous density (if I may coin that expression) in any of the lunar eclipses which I have hitherto observed.

*Forest Lodge, Maresfield,*
*11th June*, 1863.

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## *Occultation of κ Cancri by the Moon, 26th April, 1863.*
By Capt. W. Noble.

The star disappeared instantaneously at $12^h\ 3^m\ 15^s{\cdot}1$ local sidereal time $= 9^h\ 45^m\ 41^s{\cdot}42$ local mean time. Power 115 adjusted on the star.

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In the May number of the *Monthly Notices* is a paper by the Rev. W. R. Dawes on a very remarkable phenomenon observed by Mr. Copeland, near Manchester, upon the occasion of this occultation, viz., the extinction of three-fourths of the star's light just prior to its disappearance. I can only say that, as seen here, κ *Cancri* retained its intrinsic brightness up to the very instant of the Moon's covering it. I observed

with my Ross Equatoreal of 4·2 inches aperture, and although Mr. Copeland had the advantage of 0·8 inch in the diameter of his object-glass, my own instrument is one of such great and proved excellence, that I can only in his case, with great deference, suspect some optical illusion.

*Observatory, Forest Lodge, Maresfield,*
*11th June*, 1863.

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*Occultation of κ Cancri, 26th April*, 1863. By J. Vertu, Esq.

I did not think it worth communicating to the Society the observation I made of the occultation of *κ Cancri* on the 26th of April last; but the communications of Messrs. Burr and Dawes, in the *Notices* for May, induce me to send this note.

Some time before the occultation, having ascertained the position of the star, I adjusted the focus to the Moon, and was not a little surprised to find the *lumière cendrée* so strong that the complete circle was sharply defined, and some features in the *dark* part discernible; so much so that I was only a few seconds wrong in the time of occultation by estimation. Now as such is, I think, seldom if ever the case in this country at that age of the Moon (8·8 days), and notwithstanding the isolated and exceptional cases mentioned by Gruithuisen and Kunowsky, it would be desirable to ascertain the cause of such an anomaly—whether it be produced by an exceptional condition of the atmosphere, by the Sun's light being reflected on our satellite by some particular spot of the Earth's surface, or otherwise. It cannot be attributed to the instrument; for, with the same telescope and eye-piece, I watched the new Moon again, but after the sixth day I could perceive no trace of the Earth's light.

As regards the occultation, which I watched with increased attention, the star, which I followed until in contact with the Moon's edge, disappeared *instantaneously*. It seems to me highly improbable that a star—even supposing it to be double—which under a power of 1000 has given a round disk, would produce a perceptible diminution of light: I should rather attribute such an impression to the excitement produced on the retina by an intense and protracted gaze at the object.

It is true that "*Visus est acerrimus sensuum;*" but, *à fortiori*, this adage holds good in scrutinising the star in the telescope.

The telescope used in this observation is a $3\frac{1}{2}$-inch, by Troughton and Sims; power, 84.

*Nottingham, June* 11, 1863.

## *Observations of Astræa* ⑤, *and of Solar Eclipse, May* 17, 1863.
By J. Hartnup, Esq.

Observations of *Astræa* ⑤, taken with the Equatoreal of the Liverpool Observatory:—

| 1863. | G.M.T. h m s | R.A. ⑤ h m s | N.P.D. ⑤ ° ′ ″ | Star of Comparison. |
|---|---|---|---|---|
| March 3 | 8 50 43·0 | 9 57 16·96 | 75 14 49·7 | Regulus. |
| ,, 4 | 9 31 58·5 | 9 56 35·06 | 75 7 44·3 | ,, |
| ,, ,, | 9 41 56·2 | 9 56 34·79 | 75 7 41·3 | ,, |
| ,, ,, | 9 51 54·6 | 9 56 34·39 | 75 7 36·9 | ,, |

The observations are corrected for refraction and parallax. The place of *Regulus* was taken from the *Nautical Almanac*.

End of Solar Eclipse, observed with the Equatoreal of the Liverpool Observatory: —

1863, May 17 $7^h\ 10^m\ 48^s{\cdot}77$ G.M.T.

End of Solar Eclipse, observed by John Joynson, Esq., at Waterloo, near Liverpool:—

Lat. 53° 28′ 24″ N.; long. 3° 1′ 44″ W.

1863, May 17 $7^h\ 10^m\ 46^s{\cdot}5$ G.M.T.

Observed with a Refractor of 3½-inches aperture and 50-inches focal length. The time was taken from a clock which is controlled by the Normal Clock at the Liverpool Observatory.

*May* 17, 1863.

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## *Observation of Solar Eclipse*, 1863, *May* 17.
By Lord Wrottesley.

The end of the Solar Eclipse of the 17th of May was observed at my Observatory at Wrottesley, by my Assistant Mr. Hough, to take place at $7^h\ 2^m\ 17^s$, Wrottesley Mean Time. Telescope, the 11-foot Equatoreal; aperture, 7¼ inches.

The same phenomenon was observed by myself, with my 45-inch Achromatic and Baird Pocket Chronometer,* No. 2962, at $7^h\ 2^m\ 10^s$, Wrottesley Mean Time.

The error of the Transit-clock was obtained by the observation of the Transit of a Greenwich Star during the Eclipse.

* This is the instrument which I lent to Sir Leopold M'Clintock, and which accompanied him during his last Polar Expedition.

The chronometer was compared immediately after the termination.

The beginning was lost through clouds. It became clear a short time after the commencement, and then the cusps and the limb of the Moon were sharply defined, and afterwards the limb became very tremulous; it was also very much jagged, as viewed in the larger telescope, resembling the teeth of a saw.

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*Observations of Occultations of Stars by the Moon; of Eclipses of the Sun and the Moon; and of Eclipses of Jupiter's Satellites; made at the Radcliffe Observatory, Oxford.* Communicated by the Rev. R. Main.

*Occultations of Stars by the Moon.*

| Day. 1863. | Star. | Phenomenon. | Observer. | Instrument. | Oxford M.T. h m s |
|---|---|---|---|---|---|
| Jan. 27 | ϑ Arietis | Disap. | M. | Heliometer | 5 3 52·7 |
| | ,, | ,, | Q. | 10-ft. telescope | 5 3 53·5 |
| | ϑ Arietis | Reap. | M. | Heliometer | 6 21 6·2 |
| Mar. 2 | α Cancri | Disap. | L. | 10-ft. telescope | 11 42 12·6 |
| April 29 | *e* Leonis | Disap. | L. | ,, | 10 20 41·6 |
| | *e* Leonis | Reap. | L. | ,, | 11 21 43·2 |

The initials M., Q., and L., are those of Mr. Main, Mr. Quirling, and Mr. Lucas.

*Eclipse of the Sun, 1863, May 17.*

Clouds prevented the beginning of the eclipse from being accurately observed; the time noted when they had cleared away being several seconds too late.

The end was, however, well seen by Mr. Lucas with the 46-inch achromatic telescope mounted on the leads of the Observatory outside the town.

The observed Oxford Mean Solar Time of the last contact was $7^h\ 6^m\ 32^s{\cdot}4$.

*Eclipse of the Moon, 1863, June 1.*

Mr. Lucas observed the beginning and ending of this eclipse with the 10-feet telescope, near the Heliometer Dome.

The Oxford Mean Solar Times are as follow: —

| | h m s |
|---|---|
| First contact with the shadow ... | 9 41 36 |
| Beginning of total phase ... | 10 46 40 |
| Last contact with the shadow ... | 13 0 57 |

### *Eclipses of Jupiter's Satellites.*

Observed by Mr. Main with the telescope of the Heliometer: —

| 1863. | | h | m | s | |
|---|---|---|---|---|---|
| April 1 | Disappearance of 2d Satellite at | 12 | 14 | 18·5 | Oxford M.T. |
| 28 | Reappearance of 1st Satellite at | 11 | 1 | 41·0 | ,, |

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## *M. Foucault's Apparatus for producing Uniform Motion.*

(*Communicated by Lieut.-Col. R. Strange.*)

On a recent visit to Paris, M. Foucault was good enough to show me the new clock-work, just completed by the firm of Secretan, intended to drive the Great Equatoreal of the Paris Observatory.

M. Foucault has for some time been occupied with this subject, and has at length arrived at results with which he is himself perfectly satisfied, and which are also considered equally satisfactory by the authorities at the Observatory — the motion controlled by this apparatus being sensibly uniform under all possible changes in the motive force, and variations of friction and resistance.

I myself witnessed the following experiment: —The clock-work being detached from the Equatoreal (to which it had not yet been finally fitted), the full weight (about 58 lbs.) was applied; and the instrument being adjusted for rate, the revolving index was timed by a chronometer for about half an hour, during which period no sensible variation of rate of revolution could be detected. Half the driving weight was then removed without stopping or in any way readjusting the instrument, and the revolution of the index was again carefully observed, but no variation of the smallest perceptible fraction of a second could be detected.

M. Foucault assured me that the instrument had been subjected to far more severe and protracted trials than the above, and with the same results; and he affirms that, for all practical purposes, the problem of obtaining uniformity of rotation under considerable changes of resistance is absolutely solved.

I shall not attempt to describe from memory a machine of which a full account will shortly be published by its distinguished contriver, by whom this important invention has been patented in France and England. My object in mentioning the subject is to induce those who are either engaged in the

same research, or who propose ordering any contrivance of this kind, to pause until M. Foucault's arrangement is made known.

I should add, that I have M. Foucault's permission to make the above communication to the Royal Astronomical Society.

*London, June*, 1863.

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## *Ephemeris of Winnecke's Comet of Short Period, about the Time of Perihelion Passage*, 1863. By J. R. Hind, Esq.

(*From Dr. Seeling's Elements, Ast. Nach. No.* 1319.)

| Greenwich Mean Midnight. | R.A. | | Decl. | | Log. Dist. from Earth. | | Log. Dist. from Sun. | |
|---|---|---|---|---|---|---|---|---|
| 1863. | h m | m | ° ′ | ′ | | | | |
| Nov. 2 | 15 9·1 | +19·7 | −13 23 | −1 42 | 0·2569 | −77 | 9·9265 | −131 |
| 6 | 15 28·8 | 20·7 | 15 5 | 1 38 | 0·2492 | 72 | 9·9134 | 111 |
| 10 | 15 49·5 | 21·6 | 16 43 | 1 34 | 0·2420 | 66 | 9·9023 | 85 |
| 14 | 16 11·1 | 22·5 | 18 17 | 1 27 | 0·2354 | 58 | 9·8938 | 56 |
| 18 | 16 33·6 | 23·3 | 19 44 | 1 18 | 0·2296 | 49 | 9·8882 | −22 |
| 22 | 16 56·9 | 23·8 | 21 2 | 1 7 | 0·2247 | 39 | 9·8860 | +11 |
| 26 | 17 20·7 | 24·3 | 22 9 | 0 55 | 0·2208 | 28 | 9·8871 | 45 |
| 30 | 17 45·0 | 24·7 | 23 4 | 0 42 | 0·2180 | 17 | 9·8916 | 75 |
| Dec. 4 | 18 9·7 | 24·8 | 23 46 | 0 26 | 0·2163 | −4 | 9·8991 | 103 |
| 8 | 18 34·5 | 24·7 | 24 12 | −0 12 | 0·2159 | +10 | 9·9094 | 125 |
| 12 | 18 59·2 | 24·3 | 24 24 | +0 3 | 0·2169 | 23 | 9·9219 | 142 |
| 16 | 19 23·5 | 23·8 | 24 21 | 0 17 | 0·2192 | 37 | 9·9361 | 155 |
| 20 | 19 47·3 | 23·1 | 24 4 | 0 30 | 0·2229 | 49 | 9·9516 | 164 |
| 24 | 20 10·4 | 22·2 | 23 34 | 0 41 | 0·2278 | 61 | 9·9680 | 170 |
| 28 | 20 32·6 | 21·3 | 22 53 | 0 50 | 0·2339 | 72 | 9·9850 | 172 |
| 1864. | | | | | | | | |
| Jan. 1 | 20 53·9 | 20·4 | 22 3 | 0 59 | 0·2411 | 81 | 0·0022 | 172 |
| 5 | 21 14·3 | 19·3 | 21 4 | 1 5 | 0·2492 | 90 | 0·0194 | 170 |
| 9 | 21 33·6 | 18·3 | 19 59 | 1 10 | 0·2582 | 97 | 0·0364 | 168 |
| 13 | 21 51·9 | +17·4 | 18 49 | 1 13 | 0·2679 | 102 | 0·0532 | 164 |
| 17 | 22 9·3 | 16·5 | 17 36 | 1 16 | 0·2781 | 107 | 0·0696 | 160 |
| 21 | 22 25·8 | 15·6 | 16 20 | 1 16 | 0·2888 | 110 | 0·0856 | 156 |
| 25 | 22 41·4 | 14·8 | 15 4 | 1 17 | 0·2998 | 111 | 0·1012 | 151 |
| 29 | 22 56·2 | 14·1 | 13 47 | 1 16 | 0·3109 | 113 | 0·1163 | 146 |
| Feb. 2 | 23 10·3 | 13·3 | 12 31 | 1 16 | 0·3222 | 114 | 0·1309 | 141 |
| 6 | 23 23·6 | 12·7 | 11 15 | 1 15 | 0·3336 | 113 | 0·1450 | 137 |
| 10 | 23 36·3 | +12·2 | 10 0 | +1 12 | 0·3449 | +112 | 0·1587 | +132 |
| 14 | 23 48·5 | | −8 48 | | 0·3561 | | 0·1719 | |

By Dr. Seeling's elements (neglecting perturbations, which, during the present revolution, are likely to be small) the Comet should arrive at perihelion on Nov. 23·178 Mean Time at Greenwich.

*Nautical Almanac Office,*
1863, *July* 1.

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A note on the Eclipse of the Moon on June 1st, as seen at Exeter, accompanied by three drawings, which were exhibited at the Meeting, was received from Henry S. Ellis, Esq.

A note was also received from Mr. Thomas Petty, mentioning his observation on the morning of April 27 of a small but bright Comet, being in fact Comet III., 1863, see *Monthly Notice*, No. 7, pp. 226 and 227.

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## *Corrections to the Translation of Prof. Wolf's Letter, Monthly Notices, May* 8, 1863, *No.* 7.

(*Communicated by the Astronomer Royal.*)

Page 208.—The translation from the German is, perhaps a little too literal; and, to remove obscurity, the following modification is desirable:—

Lines 6 and 7, *inclose* in brackets ( ) the clause beginning with "not to enter," and ending with "in No. 13."

Lines 20, 21, and 22, *inclose* in brackets ( ) the clause beginning "when occupying myself," and ending "„ (*Argo*) Navis."

Page 228.—Line 20 from the bottom, *for* star, *read* object.

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## *Instruments for Sale.*

Astronomical Telescope and Sidereal Clock.—The Telescope is by Tully, 5 ft. 6 in. focal length, 4-in. field, with three common and four astronomical powers, from 60 to 270; rack, vertical and horizontal movements, with Vernier scale to each; mounts on a strong mahogany stand, on a patent equatoreal block; main tube screws in midships, and packs up in a mahogany case, with lamp and illuminating reflector. The Clock by Barraud. Both formerly the property of the celebrated Astronomer, Baily.—Apply to J. Stebbing, Esq., F.R.A.S., Southampton.

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MONTHLY NOTICES

OF THE

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VOL. XXIII. *Supplemental Notice.* No. 9.

*Mécanique Céleste: Observations sur la Comparaison établie par M. Delaunay entre les Expressions des Coordonnées de la Lune déduites de sa Théorie avec celles qui avaient été obtenues antérieurement.** Par M. G. de Pontécoulant.

Rien sans doute ne saurait être plus utile au perfectionnement de la théorie de la Lune que la comparaison des expressions, obtenues par des méthodes différentes, des trois coordonnées qui fixent à chaque instant la position de cet astre, et qui doivent servir à la construction des tables lunaires. Aussi M. Delaunay a fait, sous ce rapport, un travail très recommandable lorsqu'il a dernièrement comparé les résultats obtenus par M. Plana dans sa Théorie de la Lune, à ceux qu'il a déduits lui-même de la méthode qu'il a suivie pour arriver au même but; mais comme l'auteur n'a publié jusqu'à présent que l'exposition de la méthode, et que le second volume de son ouvrage, qui doit contenir les applications numériques, n'a pas encore paru, il est tout-à-fait impossible, au moins quant à présent, de découvrir les véritables causes qui ont produit les différences qu'on remarque entre quelques uns de ses résultats et ceux de M. Plana, et de décider d'une manière certaine de quel coté est l'erreur, puisque d'après le mode de comparaison adopté par M. Delaunay, ces résultats devraient être parfaitement identiques. Cependant il m'a paru d'après la seule inspection des tableaux de M. Delaunay que plusieurs des résultats qu'il présente peuvent être avec raison

* Voir les *Comptes Rendus* de l'Académie des Sciences; 1862, 1er Sémestre. (T. liv. Nos. 15, 16, 17, et 18.)

regardés comme entachés d'inéxactitude; et c'est à provoquer sur ce point une utile discussion entre les géomètres qui se sont occupés de la théorie de la Lune, pour arriver enfin à des formules parfaitement correctes, telles qu'on doit les espérer de l'état actuel de la science, que cette note est spécialement destinée.

J'examinerai successivement les expressions des trois coordonnées de la Lune, *la longitude, la latitude, et la valeur inverse du rayon vecteur*, en suivant l'ordre adopté par M. Delaunay, en négligeant d'abord comme il l'a fait les termes d'un ordre supérieur au 7e; nous négligerons également pour abréger le travail, à moins de quelques circonstances particulières, les termes indépendants de la quantité très petite $m$, ou multipliés par une puissance de cette quantité inférieure à la 3e, parceque ces termes étant indépendants de la force perturbatrice, ou ne dépendant en général que de la première puissance de cette force, il sera toujours assez facile de les vérifier et de reconnaître par conséquent la cause des anomalies qu'on remarquerait entre les résultats trouvés à cet égard par les différents auteurs. J'omettrai de même, pour abréger autant que possible cette note, les termes où les résultats de M. Delaunay, tout en s'éloignant de ceux de M. Plana, concordent avec ceux obtenus antérieurement par M. Lubbock, ou par moi, puisque les corrections qu'ils indiquent dans les valeurs données par M. Plana, peuvent être regardées désormais comme acquises à la science.

Dans les tableaux suivants je présenterai les résultats obtenus par M. Plana tels qu'ils sont donnés dans son ouvrage, et sans leur faire subir aucune transformation, et je ramenerai au contraire les résultats de M. Delaunay que je me proposerai de leur comparer, à ce qu'ils devraient être en adoptant pour l'excentricité $e$ de l'orbe lunaire et son inclinaison $\gamma$ à l'écliptique, les valeurs que M. Plana leur attribue; il m'a semblé que les différences des résultats en ressortiraient mieux, puisque ce sont en définitive les résultats de M. Plana qui doivent servir de terme de comparaison.

Dans une colonne particulière je présenterai en regard des résultats précédents, ceux que j'ai obtenus moi-même dans ma théorie des mouvements lunaires (*Théorie Analytique du Système du Monde*, t. iv.), et j'ajouterai au pied les observations succinctes qui peuvent résulter de cette double comparaison.

Les inégalités dont dépendent les différents termes que nous aurons à examiner, seront indiquées par leurs arguments dans lesquels :

D *représente la longitude moyenne de la Lune moins celle du Soleil.*
F *la longitude moyenne de la Lune moins celle du Nœud.*
$l$ *l'anomalie moyenne de la Lune.*
$l'$ *l'anomalie moyenne du Soleil.*

*Longitude.*

| s. | Termes de Plana. | Termes de Delaunay. | Théorie Analytique. |
|---|---|---|---|
| | $-\frac{39522017}{6144} m^4 e^3 e'$ | $-\frac{66621857}{6144} m^4 e^3 e'$ | $-\frac{39522017}{6144}$ A* $m^4 e^3 e'$ (a) |
| | $+\frac{3257665}{576} m^6 e'$ | $+\frac{3253129}{576} m^6 e'$ | $+\frac{3257665}{576}$ A* $m^6 e'$ (b) |
| | $+\frac{8548531}{6144} m^4 e e'$ | $+\frac{28145 37}{2048} m^4 e e'$ | $+\frac{2844993}{2048} m^4 e e'$ (c) |
| | $+\frac{307373383}{36864} m^5 e e'$ | $+\frac{103086725}{12288} m^5 e e'$ | $+\frac{307187071}{36864} m^5 e e'$ |
| | $-\frac{4173895}{6144} m^4 e e'$ | $-\frac{27148 15}{6144} m^4 e e'$ | $-\frac{2806183}{6144} m^4 e e'$ (d) |
| | $-\frac{19962409}{9216} m^5 e e'$ | $-\frac{42301831}{18432} m^5 e e'$ | $-\frac{19962409}{9216} m^5 e e'$ (e) |
| | $-\frac{489}{128} m e^3 e'^2$ | $+\frac{153}{128} m e^3 e'^2$ | $-\frac{1017}{256} m e^3 e'^2$ (f) |
| | $-\frac{6221}{192} m^2 e^4$ | $-\frac{29543}{1536} m^2 e^4$ | $-\frac{78109}{4608} m^2 e^4$ |
| | $-\frac{567}{16} m^2 e^3 e'^2$ | $-\frac{4089}{128} m^2 e^3 e'^2$ | $-\frac{3809}{128} m^2 e^3 e'^2$ |
| | $-\frac{5597}{64} m^4 e^3$ | $-\frac{11319}{128} m^4 e^3$ | $-\frac{5597}{64} m^4 e^3$ (g) |
| | $+\frac{21387}{2048} m^3 e \gamma^2$ | $-\frac{1797}{2048} m^3 e \gamma^2$ | $+\frac{2867}{2048} m^3 e \gamma^2$ (h) |
| | $-\frac{904829}{9216} m^3 e^4$ | $-\frac{343199}{3072} m^3 e^4$ | $-\frac{1181 99}{3072} m^3 e^4$ |
| | $-\frac{761227}{6144} m^3 e^3 e'^2$ | $-\frac{293497}{2048} m^3 e^3 e'^2$ | $-\frac{264025}{2048} m^3 e^3 e'^2$ |
| | $+\frac{144641579}{294912} m^5 e^2$ | $+\frac{142735019}{294912} m^5 e^2$ | $+\frac{143944619}{294912} m^5 e^2$ |
| | $-\frac{70043}{768} m^5 e'^2$ | $-\frac{61969}{864} m^5 e'^2$ | $-\frac{91129}{864} m^5 e'^2$ |
| | $+\frac{7220939}{4096} m^4 e^3 e'$ | $+\frac{7254731}{4096} m^4 e^3 e'$ | $+\frac{7273931}{4096} m^4 e^3 e'$ |

* Les termes marqués d'un A ont été verifiées par M. Adams.

| Arguments. | Termes de Plana. | Termes de Delaunay. | Théorie Analytique. |
|---|---|---|---|
| | $-\frac{245}{32}\ m\,e^4\,e'$ | $-\frac{105}{32}\ m\,e^4\,e'$ | $-\frac{35}{64}\ m\,e^4\,e'$ |
| $2D+l'$ | $+\frac{14201441}{4096}\ m^4\,e^2\,e'$ | $+\frac{44611649}{36864}\ m^4\,e^2\,e'$ | $+\frac{4791425}{4096}\ m^4\,e^2\,e'$ |
| | $+\frac{105}{32}\ m\,e^4\,e'$ | $+\frac{45}{32}\ m\,e^4\,e'$ | $+\frac{15}{64}\ m\,e^4\,e'$ |
| $2D+l$ | $+\frac{940855}{82944}\ m^6\,e$ | $+\frac{1863229}{82944}\ m^6\,e$ | $+\frac{1228925}{41472}\ m^6\,e$ |
| | $-\frac{967447}{2304}\ m^4\,e\,e'^2$ | $-\frac{963415}{2304}\ m^4\,e\,e'^2$ | $-\frac{957907}{2304}\ m^4\,e\,e'^2$ |
| | $+\frac{2354603}{8192}\ m^4\,e^3$ | $+\frac{5433089}{24576}\ m^4\,e^3$ | $+\frac{6040589}{24576}\ m^4\,e^3$ |
| $2D-l$ | $+\frac{3496767841}{2654208}\ m^6\,e$ | $+\frac{3514035745}{2654208}\ m^6\,e$ | $+\frac{3464046433}{2654208}\ m^6\,e$ (i) |
| | $+\frac{127960397}{221184}\ m^5\,e$ | $+\frac{127571597}{221184}\ m^5\,e$ | $+\frac{127960397}{221184}\ m^5\,e$ (j) |
| | $+\frac{36126953}{9216}\ m^4\,e\,e'^2$ | $+\frac{37031581}{9216}\ m^4\,e\,e'^2$ | $+\frac{37134073}{9216}\ m^4\,e\,e'^2$ |
| | $-\frac{326681}{1536}\ m^3\,e\,e'^2$ | $-\frac{322081}{1536}\ m^3\,e\,e'^2$ | $-\frac{326617}{1536}\ m^3\,e\,e'^2$ ( |
| | $-\frac{14428681}{24576}\ m^4\,e^3$ | $-\frac{8805001}{24576}\ m^4\,e^3$ | $-\frac{10219551}{24576}\ m^4\,e^3$ |
| | $-\frac{827639}{18432}\ m^3\,e^3$ | $-\frac{91071}{2048}\ m^3\,e^3$ | $-\frac{64221}{2048}\ m^3\,e^3$ |
| $2D-l-l'$ | $+\frac{1211197}{8192}\ m^5\,e\,e'$ | $+\frac{1200185}{8192}\ m^5\,e\,e'$ | $+\frac{1202189}{8192}\ m^5\,e\,e'$ |
| $2D-l-2l'$ | $+\frac{219639709}{73728}\ m^4\,e\,e'^2$ | $+\frac{218629693}{73728}\ m^4\,e\,e'^2$ | $+\frac{219825901}{73728}\ m^4\,e\,e'^2$ |
| $2D-l+2l'$ | $-\frac{46669}{128}\ m^4\,e\,e'^2$ | $-\frac{46831}{128}\ m^4\,e\,e'^2$ | $-\frac{23417}{64}\ m^4\,e\,e'^2$ |
| $2D-2l$ | $+\frac{2166605291}{884736}\ m^6\,e^2$ | $+\frac{1966421891}{884736}\ m^5\,e^2$ | $+\frac{2117652131}{884736}\ m^5\,e^2$ |
| $2D-l+l'$ | $+\frac{28272212637}{221184}\ m^6\,e\,e'$ | $+\frac{2745937561}{221184}\ m^6\,e\,e'$ | $+\frac{28272212637}{221184}\ m^6\,e\,e'$ |
| $2D-2F$ | $-\frac{168653}{18432}\ m^4\,\gamma^2$ | $-\frac{110333}{18432}\ m^4\,\gamma^2$ | $-\frac{110333}{18432}\ m^4$ |

| n. | Termes de Plana. | Termes de Delaunay. | Théorie Analytique. |
|---|---|---|---|
| $l'$ | $-\frac{3547567}{8192} m^5 e e'$ | $-\frac{241903}{8192} m^5 e e'$ | $-\frac{363727}{8192} m^5 e e'$ |
| | $-\frac{1553407}{1024} m^5 \frac{a}{a'}$ | $-\frac{2357119}{1536} m^5 \frac{a}{a'}$ | $-\frac{4628333}{3072} m^5 \frac{a}{a'}$ |
| | $-\frac{124805}{768} m^3 \frac{a}{a'} e'$ | $-\frac{123365}{768} m^3 \frac{a}{a'} e'$ | $-\frac{128485}{768} m^3 \frac{a}{a'} e'$ |
| | $-\frac{156147}{1024} m^3 \frac{a}{a'} e$ | $-\frac{155267}{1024} m^3 \frac{a}{a'} e$ | $-\frac{155267}{1024} m^3 \frac{a}{a'} e$ (o) |
| | $-\frac{14427729}{16384} m^4 \frac{a}{a'} e$ | $-\frac{14382081}{16384} m^4 \frac{a}{a'} e$ | $-\frac{14382081}{16384} m^4 \frac{a}{a'} e$ |

## *Observations.*

) Notre valeur s'accorde avec celle de M. Plana, celle de M. Delaunay ; fautive.

) Idem.

) Notre valeur revue par M. Adams, ne laisse aucun doute sur son itude.

l) Notre valeur employée dans le calcul du terme suivant qui s'accorde celui de M. Plana, est necessairement exacte.

) Notre valeur coincide avec celle de M. Plana.

) La valeur de M. Delaunay parait à la fois inexacte et de signe con- à ce qu'elle devrait être.

) Il y a soupçon d'erreur dans les calculs de M. Delaunay puisque nous accordons avec M. Plana.

) On trouve le détail du calcul de ce terme assez difficile dans les *Comptes us* de l'Acad. 1842.

) Comme ce terme dépend du terme en $m^5 e$ qui est inexact dans les s de M. Delaunay on ne saurait s'étonner de la différence qui existe nos valeurs.

) Nous nous accordons avec M. Plana.

) Notre terme employé dans le calcul d'autres quantités a donné des ats exacts, ce qui le vérifie.

) Il entre dans le calcul de ce terme des quantités qui ne sont pas données M. Plana, ce qui peut causer la différence qu'on remarque dans nos rs.

n) L'accord de notre résultat avec celui de M. Plana parait prouver suffi- ient que la valeur de M. Delaunay est fautive.

) La révision de nos calculs nous a amenés à constater l'exactitude de la r donnée par M. Delaunay.

) La révision de nos calculs nous a amenés à un accord parfait avec Delaunay.

## *Latitude.**

| Arguments. | Termes de Plana. | Termes de Delaunay. | Théorie Analytique. |
|---|---|---|---|
| $F - l$ | $-\frac{45611}{2048} m^4 e \gamma$ | $-\frac{46587}{2048} m^4 e \gamma$ | $-\frac{45611}{2048} m^4 e \gamma$ (a) |
| $F + l$ | $-\frac{2679}{128} m^4 e \gamma$ | $-\frac{2739}{128} m^4 e \gamma$ | $-\frac{2679}{128} m^4 e \gamma$ (a) |
| | $-\frac{1356205}{12288} m^5 e \gamma$ | $-\frac{710431}{6144} m^5 e \gamma$ | $-\frac{710431}{6144} m^5 e \gamma$ (b) |
| $2D - F$ | $-\frac{4548169}{442368} m^5 \gamma$ | $-\frac{4548169}{442368} m^5 \gamma$ | $-\frac{4548169}{442368} m^5 \gamma$ (c) |
| $2D + F$ | $+\frac{134555}{2048} m^3 e^2 \gamma$ | $+\frac{126875}{2048} m^3 e^2 \gamma$ | $+\frac{126875}{2048} m^3 e^2 \gamma$ (d) |
| $2D - F - l'$ | $+\frac{25493}{512} m^4 e' \gamma$ | $+\frac{158057}{4096} m^4 e' \gamma$ | $+\frac{158953}{4096} m^4 e' \gamma$ |
| $2D - F + l'$ | $+\frac{24337}{4608} m^4 e' \gamma$ | $+\frac{131363}{36864} m^4 e' \gamma$ | $+\frac{134927}{36864} m^4 e' \gamma$ |
| $2D - F - 2l$ | $+\frac{435649}{6144} m^3 e^2 \gamma$ | $+\frac{807091}{12288} m^3 e^2 \gamma$ | $+\frac{808711}{12288} m^3 e^2 \gamma$ (e) |
| $4D - F$ | $+\frac{127483}{122880} m^5 \gamma$ | $+\frac{456643}{122880} m^5 \gamma$ | $+\frac{456643}{122880} m^5 \gamma$ (f) |

### *Observations.*

(a) Nos valeurs s'accordent avec celles de M. Plana, les corrections proposées par M. Delaunay paraissent donc inéxactes.

(b) M. Delaunay adopte la rectification que nous avons fait subir au terme de M. Plana, quoiqu'il ait omis de le remarquer dans son tableau.

(c) Le terme donné par M. Plana coincide avec le mien en adoptant la formule de transformation corrigée par M. Adams. Son accord avec celui donné par M. Delaunay confirme son exactitude.

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* Il y a relativement à l'expression de la latitude une observation générale à faire; j'avais adopté dans ma théorie le coefficient du terme dépendant de l'argument de la latitude, tel qu'il est donné par M. Plana. Mais M. Adams ayant rectifié une erreur parmi les quantités du 5e ordre dans l'expression de ce coefficient†, erreur qui influe sur tous les autres coefficients de l'expression de la latitude, il faut pour en tenir compte multiplier par le facteur $\left(1 + \frac{121}{256} m^4\right)$ tous les termes de M. Plana, avant de les comparer avec nos résultats et ceux de M. Delaunay. Cette simple correction fait disparaître, comme on peut s'en assurer, une grande partie des différences qu'on remarquait entre nos valeurs et celles de M. Plana, et les réduit relativement à l'expression de la latitude à un très petit nombre de termes.

† *Comptes Rendus*, 1862, 1er Sémestre (t. liv. No. 16), p. 876.

(d) M. Delaunay adopte la correction que j'ai faite au terme de M. Plana, quoiqu'il ne l'ait point remarqué dans son tableau.

(e) Plusieurs combinaisons paraissent avoir été omises par MM. Plana et Delaunay dans la formation de ce terme.

(f) Le coefficient de notre théorie différait légèrement de celui de M. Delaunay, la rectification d'une erreur de calcul a ramené l'accord.

## *Valeur Inverse du Rayon Vecteur.*

M. Delaunay n'ayant porté l'approximation dans l'expression de la valeur inverse du rayon vecteur que jusqu'aux quantités du 5$^{e}$ ordre, et ses résultats se trouvant *à une seule* exception près parfaitement d'accord dans cette limite d'approximation, avec ceux de ses dévanciers, nous n'aurons de notre coté que de très courtes observations à présenter sur cet article.

| Argument. | Terme de Plana. | Terme de Delaunay. | Théorie Analytique. |
|---|---|---|---|
| $l$ | $-\frac{152129}{4608}\, m^4 e$ | $-\frac{153389}{4608}\, m^4 e$ | $-\frac{152129}{4608}\, m^4 e$ |

## *Observation.*

Le coefficient du terme multiplié par cos $l$ dans l'expression du rayon vecteur, se déduit du coefficient du terme correspondant ou du terme multiplié par sin $l$ dans l'expression de la longitude, on ne conçoit donc pas la correction proposée par M. Delaunay relativement au coefficient de ce terme dans l'expression du rayon vecteur puisqu'il admet le coefficient du terme correspondant dans l'expression de la longitude, tel que le donne M. Plana.

J'ai reconnu en outre, que conformement à l'observation de M. Delaunay, les 3 termes suivants devaient être ajoutés à ceux que j'avais déjà signalés comme devant être supprimés dans l'expression de la valeur inverse du rayon vecteur donnée par M. Plana :

$$\text{Arg. } 2\,D - l - l' \qquad +\frac{35}{8}\, m e^2 e'$$

$$\text{Arg. } 2\,D - l + l' \qquad -\frac{15}{8}\, m e^2 e'$$

$$\text{Arg. } 2\,D - 2\,F \qquad +\frac{3}{32}\, m \gamma^4$$

Il résulte de la discussion précédente, 1°, Que quelques unes des corrections apportées par M. Delaunay aux résultats de M. Plana, même en se bornant à l'ordre d'approximation auquel il s'est arrêté paraissent inéxactes ; 2°, Que les différences

entre les coefficients des diverses inégalités lunaires donnés par ces deux géomètres et ceux qui se déduisent de notre théorie, se réduisent en définitive à un petit nombre de termes sans importance par leur valeur numérique, et qu'on ferait du reste aisément disparaître, soit en reprenant les calculs de M. Plana, ce qui est facile puis qu'il en a donné tout le détail dans son ouvrage, soit que M. Delaunay se décide lui-même à revoir quelques uns de ses résultats avant de les livrer à l'impression. Quoiqu'il en soit, on peut régarder comme un fait très important dans la théorie du système du monde, que cette coïncidence à-peu-près complète des formules littérales qui déterminent *la longitude*, *la latitude*, et le *rayon vecteur* de la Lune, obtenues par trois méthodes absolument différentes et en portant l'approximation aussi loin que la pratique pouvait l'exiger. Ce résultat que les géomètres du dernier siècle n'avaient osé espérer, doit puissamment contribuer au perfectionnement des tables lunaires, et donner à leur construction toute la précision qu'ont acquise nos autres tables astronomiques.

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## *Further Observations on Solar Spots.*

By the Rev. F. Howlett.

It is with much pleasure that I submit to the indulgent attention of the Royal Astronomical Society a further account of observations of the Solar Spots; begging the Society to accept also the fruits, whatever they may be worth, of about eighteen months' additional honest endeavours to depict certain of those interesting phenomena which still continue to perplex the astronomical world, strongly prepossessed though some observers may be as to the theory of their character and import.

I have now the honour of laying before the Society a further series of drawings contained in about 64 sheets, comprising, first, some 128 whole disks on a scale throughout somewhat smaller than that usually employed hitherto by heliophotographers, and giving about 1 inch to $9'\,37''$ of arc. The sheets exhibit, also, secondly, several hundreds of drawings of spots and groups of spots, on a scale varying from 1 inch to about $115''$, to the considerably larger scale of 1 inch to $62''$; which last is, perhaps, as convenient and instructive a size as could well be adopted for representing the details of the solar phenomena generally, in a daily record.

As I stated at our Monthly Meeting in December 1862, the amplification last mentioned may be readily and very effectively obtained by projecting the Sun's image in a duly darkened

chamber, upon a cardboard or other screen, placed 4 ft. 2 inches from the eye-piece of a telescope (of 3 feet 8 inches focal length and $3\frac{1}{4}$ inches aperture), the eye-piece magnifying about 80 times linear, and containing a kind of micrometer, or divided-glass-diaphragm, ruled off into $\frac{1}{100}$ths of an inch, each of the divisions of which is also seen distinctly projected upon the screen, and may be brought to correspond exactly with the several half-inches of a foot-rule carefully drawn upon the screen in ink.

By the above adjustment every $\frac{1}{10}$th of an inch would, of course, represent about 4″ of arc upon the projected solar disk.

When an eye-piece of 150 is employed, and the distance of the screen therefrom is adjusted to 3 feet 8 inches, every $\frac{1}{10}$th of an inch represents 2″ of arc only; which amplification is likewise attainable by employing a power of 120, and removing the screen to a distance of 5 feet 6 inches.

I have not yet estimated the value of still higher powers in connexion with the screen, though I occasionally scrutinise the spots by their aid.

A circle of about 18 inches in diameter, marked off into 360 degrees, is also drawn upon the screen, and a plumb-line hangs before it in order to insure the perpendicularity of the line joining the degrees 0° and 180° (or any other line parallel thereto), which represents the zenith and nadir points, for the time being, of the projected solar image.

When the screen is nicely and squarely adjusted (on an easel or otherwise) before the telescope, a fiducial line showing the course that is being pursued by a spot at any given hour across the disk, may be very approximately obtained by observing at what degree any spot enters, and at what degree also it quits, the circle, and referring this line, at leisure, by a parallel-ruler to the centre of the small drawing of the solar disk for the day; upon which drawing, however, the *positions* of the spots should be carefully dotted down immediately after noticing the course pursued by any one of them across the screen. The details of nuclei and penumbræ, &c. may of course then be drawn more leisurely. But a better plan is to throw any small, neatly defined spot precisely upon the central point of the circle on the screen, and observe where it cuts the circumference, which at once (not reckoning, however, the reversion of the image) gives the radial half of the fiducial line traversed by the spot. Despatch in noting down the positions of the spots is the more imperative the nearer it may be to the hour of noon that the observation is made; whilst at about an hour and a half after 6 A.M. and the same time before 6 P.M., the positions may be taken very deliberately—the line of junction of any two spots appearing then to be nearly stationary—though this line would be seen to retrograde before 6 A.M. and after 6 P.M. Indeed, since this

paper was commenced, I have been assured by an observer,* who informs me that he went in the year 1861 to high northern latitudes with the view of taking notes in connexion with astronomical subjects (chiefly solar), that he has, when within the Arctic Circle, actually seen this retrogradation going on during the whole period between 6 P.M. and 6 A.M.: the rate of retrogradation increasing or diminishing according as the hour was nearer to or further from the period sometimes called the "midnight sun." (See also the subject alluded to in the *Monthly Notices*, vol. xxi. No. 2, page 50, for December 14th, 1860.)

My observations, and some also of my drawings of the very conspicuous group of Solar Spots which passed off the disk on the evening of the 4th August, 1862, have already been honoured with a place in the *Monthly Notices* (vol. xxiii. No. 3), and the only reasons why I would wish to allude to them again on this occasion are these:—In the woodcut, fig. 6, p. 113, owing to some mistake, an actual notch in the Sun's normal or average margin is represented in the figure; whereas, in point of fact (and this is a very important difference), what I observed and described was only a notch caused, apparently, by an abnormal heaping up of facular photospheric matter to the north and south of the position occupied by the notch P.

Then, again, I must beg permission to demur to a statement made by Herrn Spoerer in their elaborate and careful paper in the *Astronomische Nachrichten* (No. 1402, column 147), wherein they assert that by mid-day on August 4th, 1862, the penumbra of the large spot (numbered by them 79†) "extended to the Sun's extreme edge." Whereas, owing in part probably to the very serene state of the atmosphere at my station of observation, I was enabled, at the hour above mentioned, to discern an unbroken streak of photosphere between the western edge of the penumbra and the Sun's limb; and as late even as 3.50 P.M. to estimate the breadth of this streak at about 2″.

By 6 P.M. indeed, and possibly at an earlier period, I observed that the nucleus of the great spot (79 of Prof. Spoerer, and $\varepsilon$, August 4th, in my record) had entirely disappeared, portions of penumbral matter, however, reaching completely to the Sun's extreme margin: and this has been the only occasion on which I could positively assert that I have seen the penumbral matter on the very edge of the Sun, with the exception of the interesting group $\pi$, which appeared upon the disk on the morning of February 18th, 1863, and included many patches

* Mr. J. Macnider, of No. 10 Norfolk Street, Strand.

† The diameter of this spot is reckoned by Prof. Spoerer at 4140 geographical miles, which space on the solar surface would subtend an angle of little more than 9″, whereas it was really at least 85″ in diameter when seen about the middle of the disk, as on July 29th, which is equivalent to fully 38,000 geographical miles.

of penumbra, and several strongly marked faculæ, and to which I shall have occasion to allude again in the present paper.

The usual preponderance of spots in the northern hemisphere has been as apparent as ever during the eighteen months last past. Out of the 128 disks now on the table it may, I think, be shown that a northern preponderance obtained on 80 days, a southern on 43, whilst on the remaining 5 days the spots were distributed pretty equally (more particularly as regards their energy) on each side of the Solar equator. Spots prevailed in the northern hemisphere during the whole of November and December 1861, as also during the whole of January, and first half of February 1862. My observations were suspended until about April 12th, 1862, when the spots were likewise in force in the north. They then went on alternating with tolerable impartiality (so far as I observed them) till about the last week in July 1862, when the northern preponderance was again apparent till the middle of August. During the whole of September, however, the south was chiefly in activity. For the first half of October the north again had the advantage; but during the next seven weeks I was unable to continue my record, having been absent from England; though, on my return home in the first week of December 1862, I found that the north was once more in the ascendant, and so it continued till about January 12th, 1863. Southern spots then prevailed till about February 18th. They then alternated (or seemed nearly evenly distributed at times) till March 17, after which northern spots maintained their ground till April 7th. The south then showed a superiority for about a week or so, then the north for a fortnight, and then the south once more resumed the preponderance, which it continued to hold up to May 19th, 1863, when the northern spots, though sufficiently important, were far excelled in interest and number by the southern ones; after which the northern spots altogether predominated till the end of May 1863. As, however, it is by no means an easy matter to determine always the precise line of the Sun's equator or of his parallels of latitude, I offer certain of the above particulars subject to correction.

During the past eighteen months the only day on which the Sun was observed by me to be devoid altogether of spots was the 9th April of the present year. I did not, however, scrutinise the disk very closely on the day in question, and certainly a small nucleated spot was visible on the 10th, about one minute from the Sun's preceding limb, and possibly, therefore, it may have been in existence on the day previous.

As a general rule spots have been tolerably plentiful on most days ever since the year of their estimated maximum in 1859; and their minimum period must not be expected before 1865 or 1866; reckoning, that is, from data collected by M.

Wolf, of Berne, and cited by Sir John Herschel in his *Outlines of Astronomy* (Ed. 1858), section 394[a].

There is a peculiar curvilinear arrangement of minute spots and patches of penumbræ, generally concentric, with a larger nucleated spot or group of spots, which I have not unfrequently noticed; and which, as well also as a highly interesting double, or sigmatoid curve, assumed sometimes by the little subordinate spots and patches, would seem to bear strongly upon the theory of cyclones upon the Sun's surface. These phenomena are recorded in sheets 73, April 30th, and 77, June 4th, 1862; in 99, Feb. 16th; 110, April 19th; 111, April 21st; and 115, May 11th, 13th, and 15th, 1863.

By the use of the screen I have obtained a far better insight than I could otherwise have had into the appearances and general disposition of those remarkable solar phenomena, the Faculæ. As is well known, these rarely or never occur in either high northern or southern latitudes, though they abound commonly in the zones occupied by the spots. Their forms are very varied, and often very fantastic. Sometimes they exist as small amorphous patches; sometimes they are stellate; at other times they assume a kind of reticulated or anastomosing appearance, or (as Profs. Spoerer observe) that of the circular lunar craters. Not unfrequently I have noticed them closely resembling the "merry-thought" of a bird, or even grotesque attenuated human figures. These appearances may be noted in the order in which they are mentioned in sheets 106, 122, 107, 109, 108, 114, &c.

The Faculæ are not only to be seen when near to the eastern or western limb of the Sun, but often also when quite on the central portions of the disk, where, if I interpret rightly certain appearances frequently presented on the screen, their existence may, amongst other forms which they are apt to assume, be detected as narrow, irregular, faintly luminous borderings, from about 4″ to 8″ in width, immediately surrounding *some*, though not all of the larger spots; and this luminosity appeared to me to be caused by an extra thickening of the photospheric matter by which the spots are surrounded, and by the absence, as a natural consequence, of that peculiar porous, curdled, and comparatively dusky appearance (caused in all probability by the interstices between the so-called "willow-leaves," or perhaps small aggregations of the willow-leaves of Mr. Nasmyth) which characterises the whole of the solar surface not actually occupied by the spots or faculæ. Moreover, I do not think that the faint borderings round the spots above alluded to are the effect of any instrumental or optical illusion, as I at first rather suspected.

A representation of their general appearance may be seen in sheet 99 of my record, under date Feb. 16th, 1863.

There is another point which may perhaps have been

noticed by other observers, but which I think well merits attention in any theorisings upon the constitution of the Sun: I allude to the frequently remarkable *persistency* of some of the smaller and more isolated spots, whether situated either more remote from or nearer to the Sun's equator. Whilst the contour and the details of the larger groups may be seen frequently to undergo a complete transformation during their passage across the disk, so that *hundreds of millions* of square miles of spots and penumbral matter are either entirely disposed of or so changed and re-arranged that it becomes impossible to recognise them under their new forms, it often happens, in the case of some of the smaller isolated spots, that one of not more, perhaps, than 5″ or 6″ in diameter (which small quantity, however, on the solar surface would imply a superficial area of from five to seven million square miles*) will be seen to maintain a nearly unaltered appearance for several consecutive days.

I have on previous occasions given in my humble adherence to the theory that the Solar Spots are cavities in the surface of our luminary, the nuclei being the most deeply sunk portions, the penumbra commonly shelving down to them on all sides from the external photosphere; though at the same time I had generally found that the penumbræ possessed only an exceedingly slight amount of depression within the solar surface. Very palpable evidence of this latter fact was afforded, as it seemed to me, by the fine group $\pi$ of the 18th Feb. 1863, already mentioned (sheet 99). The group in question consisted of two somewhat contiguous large spots, accompanied, as it afterwards proved, by many faculæ and numerous smaller spots, and detached patches of penumbra. But so broadly conspicuous (as seen projected on the screen) were the nuclei of both the contiguous large spots, and so completely devoid was the most westerly nucleus of *any measure* of penumbra on its eastern (following) edge, that I not only was more strongly convinced than ever of the extreme shallowness of the penumbral depressions, but I even for a while wondered whether, after all, they and the nuclei could be depressions at all!

The two nuclei were distant, respectively, about 15″ and 30″ from the Sun's limb at the moment when I experienced these doubts; but when the group was well advanced upon the disk (as it was by Feb. 21, when I next observed it), it was evident that I could not have seen any penumbra upon the eastern side of the great westerly nucleus, for the simple reason that it proved to be devoid of any in that direction;

* 1″ subtends 450 miles. Therefore,

$(5'' \times 450)^2 = 5{,}073{,}750$ square miles

and, $(6 \times 450)^2 = 7{,}290{,}000$ ,, ,,

whilst conversely the easterly large spot proved to have but comparatively little penumbra upon its western (preceding) side, and what little it had would doubtless have been still further diminished to sight on the 18th by the effect of foreshortening, as first described by Dr. Wilson. It was on this same day (Feb. 18th, 1863) that I observed, for the second time only within my experience, that the penumbral matter in straggling connexion with the most easterly spot of group $\pi$ extended absolutely to the Sun's edge, and surrounded, evidently, the northern extremity of a conspicuous mass of faculæ which extended along the limb of the Sun; many other facular streaks also occurring in the neighbourhood of the spots, and extending uninterruptedly to the great group lettered $\varrho$, which lay about $2' 25''$ to the north.

A group possessing many features in common with the one just described as group $\pi$ came upon the disk on the morning of April 12th, 1863, and in neither of the two principal spots was I able to trace much appearance of penumbra on the eastern side of their respective nuclei; but the details of the group had suffered such extensive changes by April 15th that the appearances they exhibited, when well on the disk at the latter date, could by no means be appealed to for evidence as to what might have been the disposition of the various nuclei and penumbræ on the 12th of the same month. I had observed these changes going on during the interim, but was unable to secure drawings of them. I particularly noticed, however, that the most westerly spot, lettered $\eta$ 5, had shrunk to about one-fourth of the magnitude it had possessed on entering the disk.

Since the Meeting in May last I have observed and drawn an unusually interesting group, as shown in sheet 115, under date May 11th, 1863, and letter $\xi$ of my record. Both the principal spot, as well as from twenty to thirty much smaller subordinate ones, appeared to be obeying some strongly vorticose impulse during this period of their development. Starting either from a small group of faint penumbral patches situated about $45''$ to the east, or more probably, as I thought, from a more considerable spot about $18''$ in length, lying $12''$ or so to the north-east of the principal spot, they had formed around this latter for fully half the circumference of a circle, adopting a curious, bifurcating, diverging course, bearing no inconsiderable resemblance to the spiral structure of some of the great nebulous clusters of stars, as revealed in Lord Rosse's gigantic reflecting telescope.

I did not see the group $\xi$ again until the morning of May 13th, when its whole appearance was as much changed as could well be conceived. The small detached eastern group above alluded to had developed into a large elongated trifid connected spot, fully $1' 17''$ in length from north-west to south-

east, and containing three or four easily-discerned nuclei; whilst the other series of small spots (which had presented, two days previously, that peculiar spiral arrangement) were replaced also by a large, very irregular confluent group, about 1′ 30″ in length, likewise extending from north-west to south-east, and comprising six or eight small nuclei, which were represented by three very much larger ones on the day following (May 14th), when I last observed them.

Moreover, on May 13th, a line of faint and somewhat remotely separated penumbral specks swept through the midst of group ξ in a delicate sigmatoid curve (very similar in its character to the sigmatoid curve observed by me on April 30, 1862), which appeared to indicate the existence of some common and extensive influence then at work throughout the whole system of the aggregate group, and which curve may also be seen to bifurcate at a point not far from equidistant between the principal spot and the north-west extremity of the trifid easterly group.

It is also, perhaps, worthy of note that, whilst from these and some other of my drawings it is apparent that the nuclei sometimes preceded the formation of their penumbræ, at other times the reverse was the case; for I presume that the illustrious Kirchhoff would by no means wish to assert that the former case always holds good, as one might almost seem to gather from a passage (p. 27) of Prof. Roscoe's translation of Kirchhoff's *Researches on the Solar Spectrum and the Spectra of the Chemical Elements.*

I have only one more subject to mention, and that is, that I hope some one else besides myself took notice of and depicted, or, better still, secured a photograph of, a most curious phantom-looking group of spots which, at 1 P.M. on the 4th January of this present year, exhibited an appearance so wonderfully like a human skeleton, that, in a less superstitious age than the nineteenth century, its portentous shape might easily have raised considerable apprehension in the minds of the multitude.

Being Sunday when this was observed, and being much occupied with the more immediate duties of my profession, I did not draw the group with micrometric correctness, but simply took a rough sketch of the phantom, which subtended about 5′ 40″ of arc, or 153,000 miles, and respecting which (as I observed lately to Admiral Manners) I am really not aware that any love for the marvellous induced me to exaggerate in any degree the singularity of its proportions.

Sheet 96 exhibits this group as it appeared, when much altered, on Jan. 7th.

## *On Eyepieces.*

(*Extract of a Letter from the Rev. W. R. Dawes.*)

I have seen enough of the three eyepieces you sent to report upon them with some confidence.

1st. The *Airy* (marked with pencil 271).* I cannot believe this to be a fair representation of the proper combination of curves pointed out by Mr. Airy. The field is by no means large, and towards the edge there is a very decided red fringe. It is vastly inferior to any ordinary astronomical Huyghenian eyepiece I possess, as constructed by Dollond, Ramsden, and Tulley. The angular subtense of the diaphragm is 37° 57′, and of that small angle not more than about 25° are good.

2. The *Kellner* (as it professes to be) is also an unfair specimen of his construction, the diaphragm being *considerably too small.* The angular subtense is only 37°·35; but the distinctness at the very edge of the field is scarcely less than in the centre, and gives the impression that the angular subtense of the diaphragm might be advantageously enlarged to at least 48° or 50°.

3. The *Aplanatic* has a very large field, and is pleasantly *achromatic* to the edge; but the exterior 4° or 5° of the angular subtense of the diaphragm (which = 59°·47) are far from distinct; and I doubt whether much more than 50° out of the whole subtense would be sufficiently so. To determine this, however, with exactness, would require careful observations on a fine night; and I have not been able to spare the *fine* starlight for the purpose. This eyepiece has a double ghost when a bright object is in the field.

An ordinary *Ramsden* Huyghenian which I have has a perfectly distinct and achromatic angular subtense of 48°.

In a *Kellner's* eyepiece, *made by himself*, the angular subtense = 49°·56: admirably distinct and achromatic to the edge.

In a *Dollond* Huyghenian, the angular subtense = 46°·46: nearly perfect throughout.

In a *Tulley* Huyghenian, the angular subtense = 51°·84: extremely fine in colour and distinctness.

These, you will see, are scarcely, if at all, inferior to the "*Aplanatic*," and have far less of ghostly appendages.

*Hopefield Observatory, Haddenham, Thame,*
*April* 9, 1863.

* The Astronomer Royal remarks that he has never seen this eyepiece, and knows nothing about it.—Ed.

## *To the Fellows of the Royal Astronomical Society.*

Gentlemen,—The accompanying Letter has been addressed to me for the purpose of communication at our first Meeting on November 9; but, for obvious reasons, I have thought it more advisable to circulate it without delay.

I am, Gentlemen,
Your obedient Servant,
C. PRITCHARD.

*Somerset House, Oct.* 24, 1866.

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### *The November Meteors* 1866.

*To the President of the Royal Astronomical Society.*

Sir,—As the attention of Astronomers to the appearance of the Great November Shower has lately been aroused by a prediction of Professor Newton that the November Meteors will return in the present year; and as the prediction is advanced upon grounds so purely astronomical that it is not in the least degree likely that it will be contradicted by the event, I scarcely need to apologize to you for requesting you to give your consideration to a short account of the chief points of interest to observe, or upon which the attention of observers will be most profitably bestowed.

The main body of the meteors is expected to visit the western shores of the Atlantic Ocean towards sunrise on the morning of the 14th of November. In the absence of the Moon darkness may be expected to add an exceptional character to the display, both for the numbers and brilliancy of the meteors, and for the peculiar features of leaving trains, &c., by which they are distinguished. Should it happen a few hours earlier than the predicted time, the maximum, instead of being visible in America, will be visible in Europe. For two years past, the 13th rather than the 14th of November has, in fact, been the principal date of the display. A strict watch for the return of the maximum display in England is accordingly recommended to be kept on both of the mornings of the 13th and 14th of November, by counting the number of the meteors at intervals or continuously from midnight until sunrise. Several observers might combine together, and dividing the points of the compass equally between them, one person might register for all. so as to avoid the possibility of repetition or of count-

ing the same meteor twice. The number of the observers should be stated, as well as the condition of clouds or the proportion of clear sky.

The planet *Venus*, when seen in the evening near its greatest brightness, is a suitable object for comparison with the meteors. Ordinary shooting-stars may be compared with the magnitude of the fixed stars, and larger meteors with the diameter of the Moon.

The duration of a meteor's light, or of its streak, may, after a little practice, be recorded very nearly to a sixth part of a second, by repeating letters of the alphabet immediately after the disappearance of the meteor. In the case of the most enduring streaks it is important to observe through the prism of a direct-vision spectroscope if the yellow line of sodium, or if the light of any other substance in combustion, is very brilliant in the spectrum of the streak.

During the hour from one to two o'clock, on each morning, a strict watch is recommended to be kept, with a view of obtaining as many simultaneous observations of meteors as possible at distant places. The following particulars of each meteor seen should then be recorded, viz.:—The instant of appearance to the nearest second of Greenwich time; the brightness, colour, and duration of the meteor, and of its streak; and its direction, as from one star, or from one part of one constellation to another, or the place of its first appearance and the point of its disappearance by an altazimuth instrument; or otherwise. Any peculiarity of its appearance, as if it changes its light or colour, or if it bursts, should be recorded. More observations will also be made in the interval from one to two o'clock, if the labour is divided with an assistant, who would register the time (by a good seconds' watch), and the other particulars of the observation in writing. For some minutes after the bursting of very large meteors any noise should be attentively listened for, noting the intervening time. Auroras should also be looked for and distant lightning.

The paths of the meteors prolonged backwards cross each other at a point about the centre of the "sickle" in the constellation of *Leo*, from which point all the meteors appear to emanate. To fix the exact position of the point and to map as many meteors as possible on each morning during the interval from one to two o'clock, the Luminous Meteor Committee's Star-maps are distributed to experienced observers, who have already availed themselves to useful purpose of their skill in this kind of observations.

By means of the maps and by attending to these directions the meteoric shower, it is expected, will be so well observed in England as to afford useful materials for discussion and for comparison with materials obtained at other places.

I am, Sir, your obedient Servant,

A. S. Herschel.

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